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Microwaves & RF

News
SUSS's brand of Vermont technology

Design Feature
Revisit models for oscillators

Product Technology
Integrated power amp drives four cell bands

Low-Power DDS Scales 80-dB Dynamic Range

Communications Issue

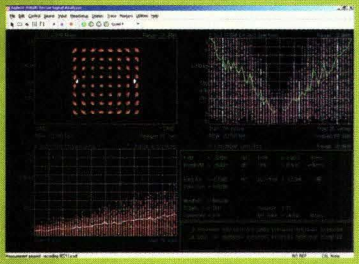
#BXNPGNX *********************AUTO**3-DIGIT 543
#533579017 5# RF 001 100 SCK 506
JOE LORITZ, ENGINEER
GBPPR
424 WILSON AV
GREEN BAY WI 54303-4115

The original idea was simple: use wireless links to give the wired generation more mobility. Of course, turning *Bluetooth* and Wi-Fi into reality—without much time for analysis—has been anything but simple. Perhaps we can help.

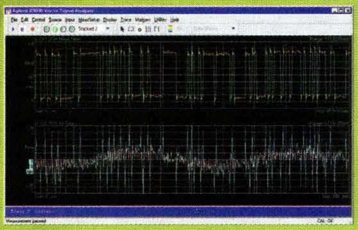
Enhancing interoperability. Many people attribute Wi-Fi's popularity to WECA testing that certifies device interoperability. Those who've passed tell us the roots of success often reach back to early tweaks in their transmitter or receiver designs. For transmitters, error vector magnitude (EVM) versus time or channel is a measure of modulation quality that can highlight underlying problems such as nonlinear distortion, phase noise and spurious signals. Conversely, making receivers more forgiving of nonideal transmitters can come from testing with impaired signals—in hardware, simulation or a system that links both.

Achieving certification. The Agilent Interoperability Certification Labs and Agilent's network of test partners are ready to help, too: they've tested hundreds of Wi-Fi devices and can help you clear the qualification hurdle.

To learn more, please visit www.agilent.com/find/wn, where you can request a FREE CD-ROM packed with articles, solution guides, and application notes such as "RF Testing of Wireless LAN Products" and "Verifying *Bluetooth* Baseband Signals."



For this IEEE 802.11a signal, the overall EVM measurement is acceptable but viewing EVM versus time (lower left) and channel (upper right) shows the effect of a timing error.



The FSK error display can highlight the effects of unwanted frequency modulation, which may indicate the presence of spurious signals in the modulator.

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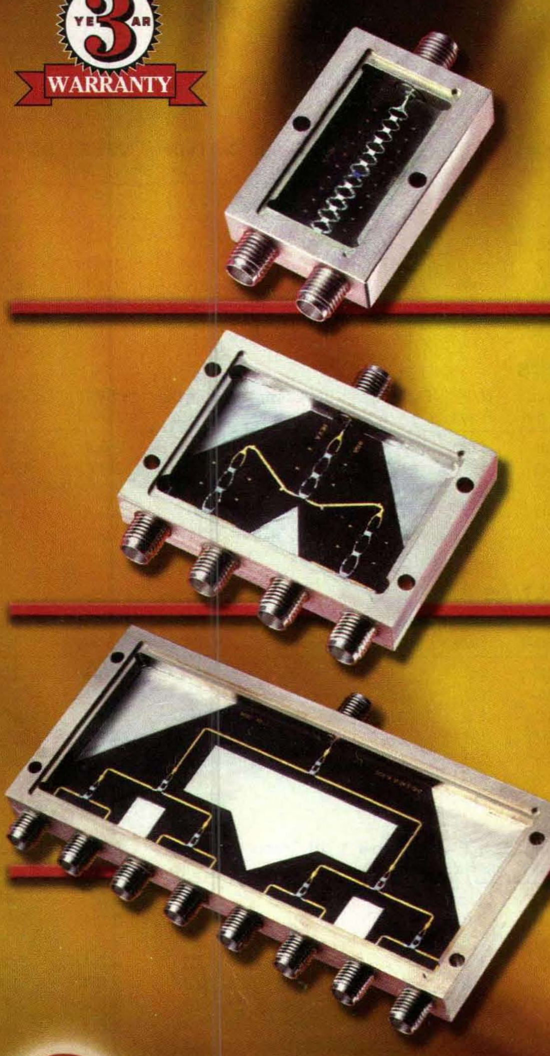

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2 Way Power Divider - Model D0289			
RF frequency range	GHz	18	40
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Isolation	dB	17	
Input VSWR	Ratio		1.8
Output VSWR	Ratio		1.7
Phase unbalance	Degrees		±5.0
Amplitude balance	dB		±0.5
4 Way Power Divider - Model D0489			
RF frequency range	GHz	18	40
Insertion loss	dB		2.5
Isolation	dB	17	
Input VSWR	Ratio		1.8
Output VSWR	Ratio		1.7
Phase unbalance	Degrees		±5.0
Amplitude balance	dB		±0.5
8 Way Power Divider - Model D0889			
RF frequency range	GHz	18	40
Insertion loss	dB		3.5
Isolation	dB	17	
Input VSWR	Ratio		1.8
Output VSWR	Ratio		1.7
Phase unbalance	Degrees		±5.0
Amplitude balance	dB		±0.5

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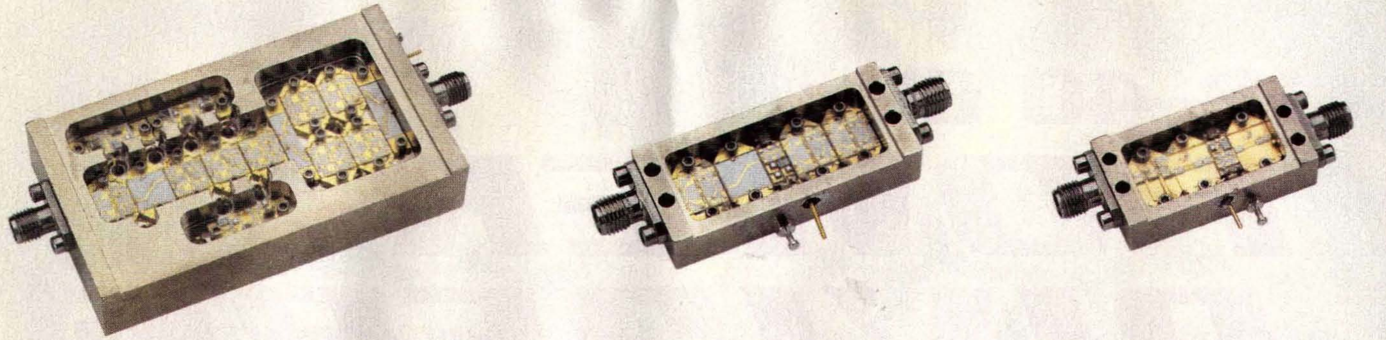

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Ultra broadband

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-203	0.5–18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5–18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0–18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0–18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0–18.0	30	5.0	2.5	21	31	2.0:1	500

Multi-octave amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA04-403	0.5–4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5–8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0–8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0–12.0	32	5.0	3.0	14	24	2.0:1	550
JCA618-406	6.0–18.0	20	6.0	2.0	25	35	2.0:1	600
JCA618-507	6.0–18.0	25	6.0	2.0	27	37	2.0:1	800

Medium-power amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35–1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1–3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9–6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0–12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0–18.0	22	4.0	2.0	25	35	2.0:1	700

Low-noise octaveband LNAs

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-3001	1.0–2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0–4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0–8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0–12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-800	12.0–18.0	45	2.0	1.0	10	20	2.0:1	250

Narrowband LNAs

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2–1.6	25	0.75	0.5	10	20	2.0:1	80
JCA23-302	2.2–2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7–4.2	30	1.0	0.5	10	20	2.0:1	90
JCA56-401	5.4–5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25–7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0–9.5	25	1.3	0.5	13	23	1.5:1	150
JCA910-3001	9.5–10.0	25	1.4	0.5	13	23	1.5:1	150
JCA1112-3000	11.7–12.2	27	1.4	0.5	13	23	1.5:1	150
JCA1213-3001	12.2–12.7	25	1.4	0.5	10	20	2.0:1	200
JCA1415-3001	14.4–15.4	35	1.6	1.0	14	24	2.0:1	200
JCA1819-3001	18.1–18.6	25	2.0	0.5	10	20	2.0:1	200
JCA2021-3001	20.2–21.2	25	2.5	0.5	10	20	2.0:1	200

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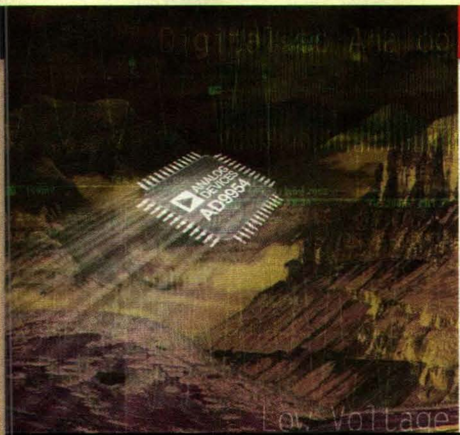

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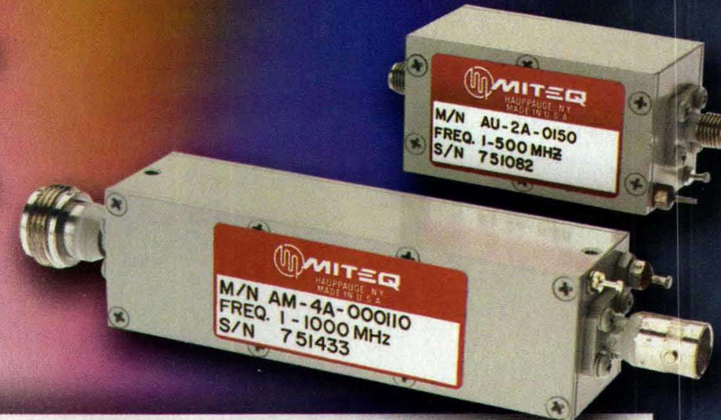

OPERATING FREQUENCY (MHz)	MODEL NUMBER	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	VSWR IN/OUT	NOISE FIGURE (dB, Max.) NF_1	NF_0	NF_2	OUTPUT POWER (dBm, Min.)
0.001 – 500	AU-1534	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 200	AU-1442	35	0.5	2.0:1	1.2	1.2	1.2	+5
0.01 – 200	AU-1447	56	0.5	2.0:1	1.2	1.2	1.2	+12
0.01 – 250	AU-1559	11	0.5	2.0:1	4.2	4.2	4.2	+16
0.01 – 400	AU-1565	54	0.75	2.0:1	1.2	1.2	1.3	+14
0.01 – 500	AU-1310	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 1000	AU-1402	18	1.0	2.0:1	6.0	5.0	5.0	+16
0.01 – 1000	AM-1300	27	0.75	2.0:1	1.4	1.6	1.8	+8
0.01 – 1000	AM-1431	35	0.75	2.0:1	1.4	1.6	1.8	+8
0.1 – 2000	AM-1364	9	1.5	2.0:1	6.0	6.0	6.0	+10
1 – 200	AU-1464	35	0.5	2.0:1	1.2	1.2	1.2	+6
1 – 400	AU-1421	24	0.5	2.0:1	2.4	2.4	3.1	+17
1 – 500	AU-2A-0150	30	0.5	2.0:1	1.3	1.4	1.5	+8
1 – 500	AU-3A-0150	44	0.5	2.0:1	1.3	1.4	1.5	+10
1 – 500	AU-4A-0150	60	0.75	2.0:1	1.3	1.4	1.5	+10
1 – 1000	AM-2A-000110	26	0.75	2.0:1	1.4	1.6	1.8	+6
1 – 1000	AM-3A-000110	35	0.75	2.0:1	1.4	1.6	1.8	+8
5 – 200	AUP-1568	26	0.75	2.0:1	5.0	4.5	4.5	+28
5 – 300	AUP-1495	11	0.75	2.0:1	15	9.0	9.0	+28
5 – 300	AUP-1496	23	0.75	2.0:1	8.0	7.0	7.0	+28
5 – 300	AU-1021	24	0.5	2.0:1	2.7	2.8	2.9	+20
5 – 300	AUP-1479	36	1.0	2.0:1	2.5	2.7	2.9	+28
5 – 1000	AM-1475	36	0.75	2.0:1	1.4	1.6	1.8	+15
5 – 2000	AM-1573	18	1.5	2.0:1	4.0	4.0	4.0	+21
5 – 2000	AM-1590	36	2.5	2.0:1	3.8	3.8	3.8	+20
5 – 2000	AM-1591	48	2.5	2.0:1	3.8	3.8	3.8	+20
100 – 1000	AM-1412	35	0.75	2.0:1	1.4	1.6	1.8	+14
100 – 2500	AM-1585	26	2.0	2.0:1	3.6	3.6	3.6	+20
200 – 2000	AM-1569	20	1.5	2.2:1	4.2	4.3	4.6	+14
1000 – 2000	AM-1477	37	1.0	2.0:1	1.8	2.1	2.4	+15

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The "Team" Concept

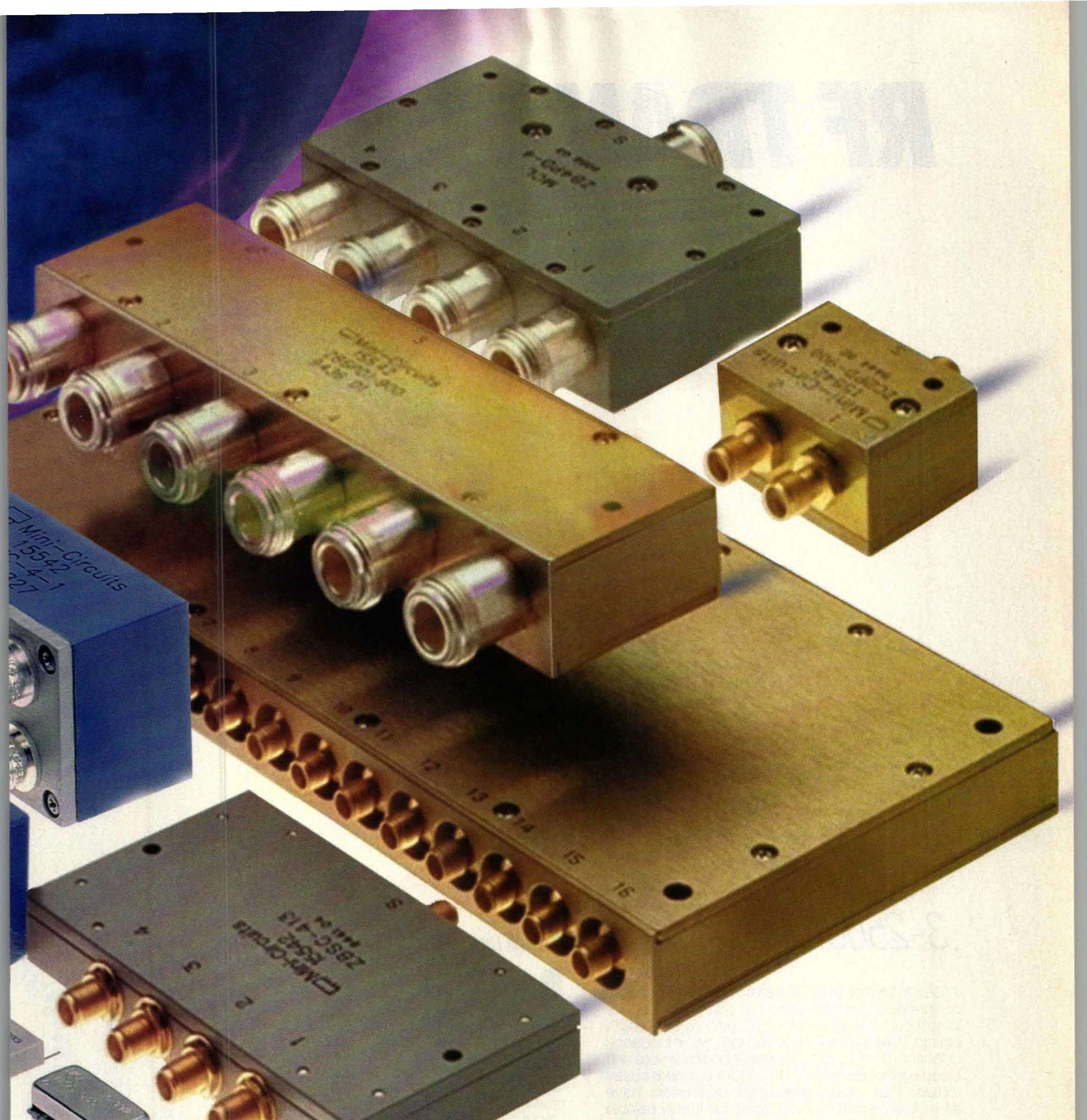
Editor's Note: This letter is continued from the November issue.

▶▶AS I WRITE THIS letter, the RF electronics industry continues to suffer. Many colleagues have been laid off, sales are slumping, and there is pessimism regarding the RF industry. After all, how many different kinds of phones do we need? Should we really be spending money on software so that we can play games on our phones or surf the Internet? How many more gadgets do we need to be playing with while we are driving our cars? Isn't the US saturated with enough ways to communicate?

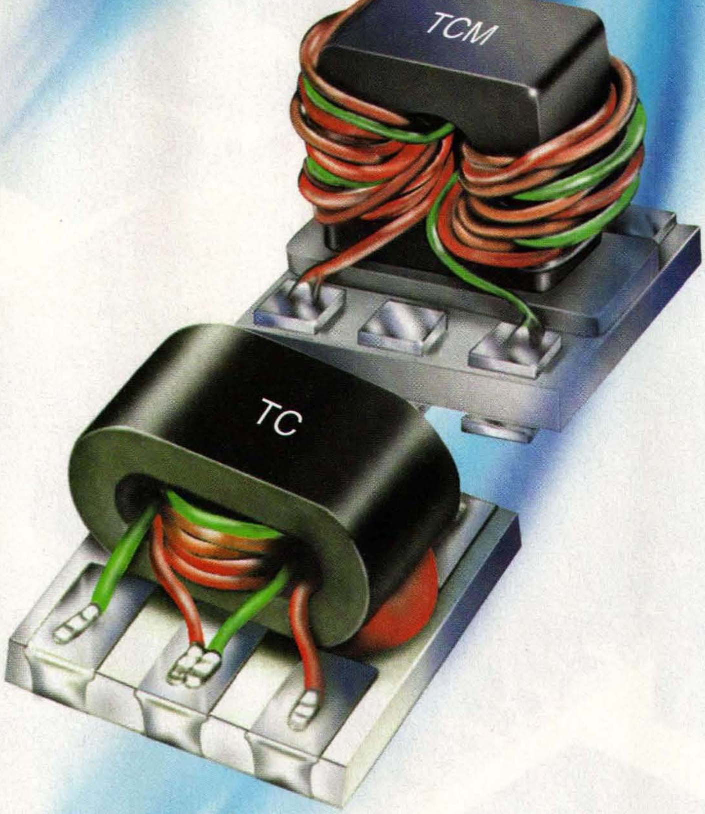
While all around us the RF industry is looking grim, it may be time to start understanding and applying the concept of the engineering team once more. This is not just another program—it's a mind-set. All levels of engineering and management must be convinced of it in order for the RF and microwave industry companies to return to higher levels of success, or simply to survive during a more challenging business environment. Let's start putting people together on projects, and co-locating them so that conversation and brainstorming is easily facilitated. Let's get the more mature and senior engineers back with the younger guys, and encourage them to spend more time with the troops. (Where have all the middle-aged and older bench engineers gone? We need them!) Some mature engineers seem to have forgotten that younger engineers like mentors, someone who stops by once in a while to discuss a problem or help fix a problem in a circuit or simulation. With cycle times decreasing, and system complexity increasing, many younger engineers feel overwhelmed with the projects that they are trying to finish. Is giving a manual to a new engineer or an engineer who is new to a topic a better idea than connecting said engineer with a more-experienced engineer, and have him explain the basics and maybe give him/her a resource to take back to their bench?

I see the grass from one side of the fence, and believe that it is greener on the other side. In some cases it is true. What is your company doing to retain their best talent, train their younger and even experienced engineers, and maintain an atmosphere of productivity? Do you love your job, and look forward to coming in, or have you become disillusioned, as many have, during these lean times? If you have answers, please consider sharing them with the editor of this fine publication. Competition amongst companies can be harsh at times, but we can come to the table and discuss ways to improve our industry.

John David
Company name withheld



RF TRANSFORMERS



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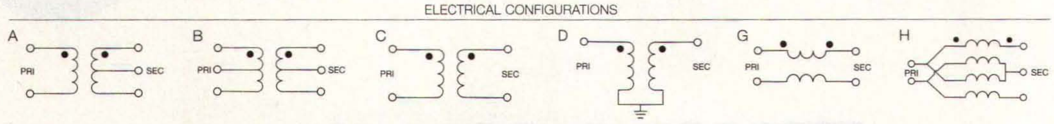
TCML1-11	1G	600-1100	700-1000	1.09
TCML1-19	1G	800-1900	900-1400	1.09
TCM2-1T	2A	3-300	3-300	1.09
TCM3-1T	3A	2-500	5-300	1.09
TTCM4-4	4B	0.5-400	5-100	1.29
TCM4-1W	4A	3-800	10-100	.99
TCM4-6T	4A	1.5-600	3-350	1.19
TCM4-14	4A	200-1400	800-1000	1.09
TCM4-19	4H	10-1900	30-700	1.09
TCM4-25	4H	500-2500	750-1200	1.09
TCM8-1	8A	2-500	10-100	.99
TCM9-1	9A	2-280	5-100	1.19

CERAMIC CASE

Model	Ω Ratio & Config.	Freq. (MHz)	Ins. Loss❖ 1dB (MHz)	Price $ea. (qty. 100)
TC1-1T	1A	0.4-500	1-100	1.19
TC1-1	1C	1.5-500	5-350	1.19
TC1-15	1C	800-1500	800-1500	1.29
TC1.5-1	1.5D	.5-2200	2-1100	1.59
TC2-1T	2A	3-300	3-300	1.29
TC3-1T	3A	5-300	5-300	1.29
TC4-1T	4A	.5-300	1.5-100	1.19
TC4-1W	4A	3-800	10-100	1.19
TC4-14	4A	200-1400	800-1100	1.29
TC8-1	8A	2-500	10-100	1.19
TC9-1	9A	2-200	5-40	1.29
TC16-1T	16A	20-300	50-150	1.59
TC4-11	50/12.5D	2-1100	5-700	1.59
TC9-1-75	75/8D	0.3-475	0.9-370	1.59

Dimensions (LxW): TCM .15" x .16" TC .15" x .15" ❖Referenced to midband loss.

ELECTRICAL CONFIGURATIONS



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377 Rev. A

from the editor

A Time For Remembrance

TIME IS CONTINUOUS, and sometimes likened to a river, with eddies and currents flowing within the whole. But try as we might, we cannot stop it, only pause in our own thinking to reflect over some portion of it and how it has impacted our lives and the lives of those around us. December usually provides a convenient point each year for remembrance along the ever-flowing river that is time.

There are always those companies that thrive, sometimes for unexplainable reasons, even during the worst of times.

Of course, for many 2002 was a year they would rather forget. Very few companies in the high-frequency industry can stake claims to 2002 as a high-water mark in their financial histories. Only a handful can admit to growth compared to the previous year, in a year when even flat sales for 2002 compared to 2001 could be considered a triumph.

Still, there are always those companies that thrive, sometimes for unexplainable reasons, even during the worst of times. For example, Scott Newman, president of Voltronics Corp. (Denville, NJ), has noted a strong demand for his company's trimmer capacitors and other components. One of the more visible success stories in the industry, RF Micro Devices (Greensboro, NC) continued a pattern of growth in 2002 that has seen the company expand from about 20 people in the early 1990s to more than 1500 employees at present (and still hiring).

Hillar Kiiss of MITEQ (Hauppauge, NY) reports that 2002 has been a good year for the company, with a growing demand for the firm's components and subsystems in military-based applications. Focus Microwaves (St. Regis, Quebec, Canada) has reported sales levels on a part with 2001. And Meta Rohde of Synergy Microwave (Paterson, NJ) has admitted that while not a banner year, her company has held its own. She does caution, however, that current unemployment figures tend to be misleading since they represent only those actively collecting unemployment and not the growing number of unemployed workers whose unemployment benefits have run out (and who are thus no longer included in the unemployment statistics).

Admittedly, these positive notes are just a small sample based on personal experience (and apologies to those overlooked here). Still, these firms deserve recognition for what they have accomplished during difficult times, and what their efforts mean to the families of their employees. For various reasons, including having the right products, the right quality, being in the right markets, treating their customers the right way, they have fared well. In doing so, they send a message to the rest of us that it can be done. And if we follow their guidelines for success, the look back from December of 2003 will be much more enjoyable. For now, much health and happiness to you all.

Jack Browne

Publisher/Editor

Microwaves & RF

A Penton Publication

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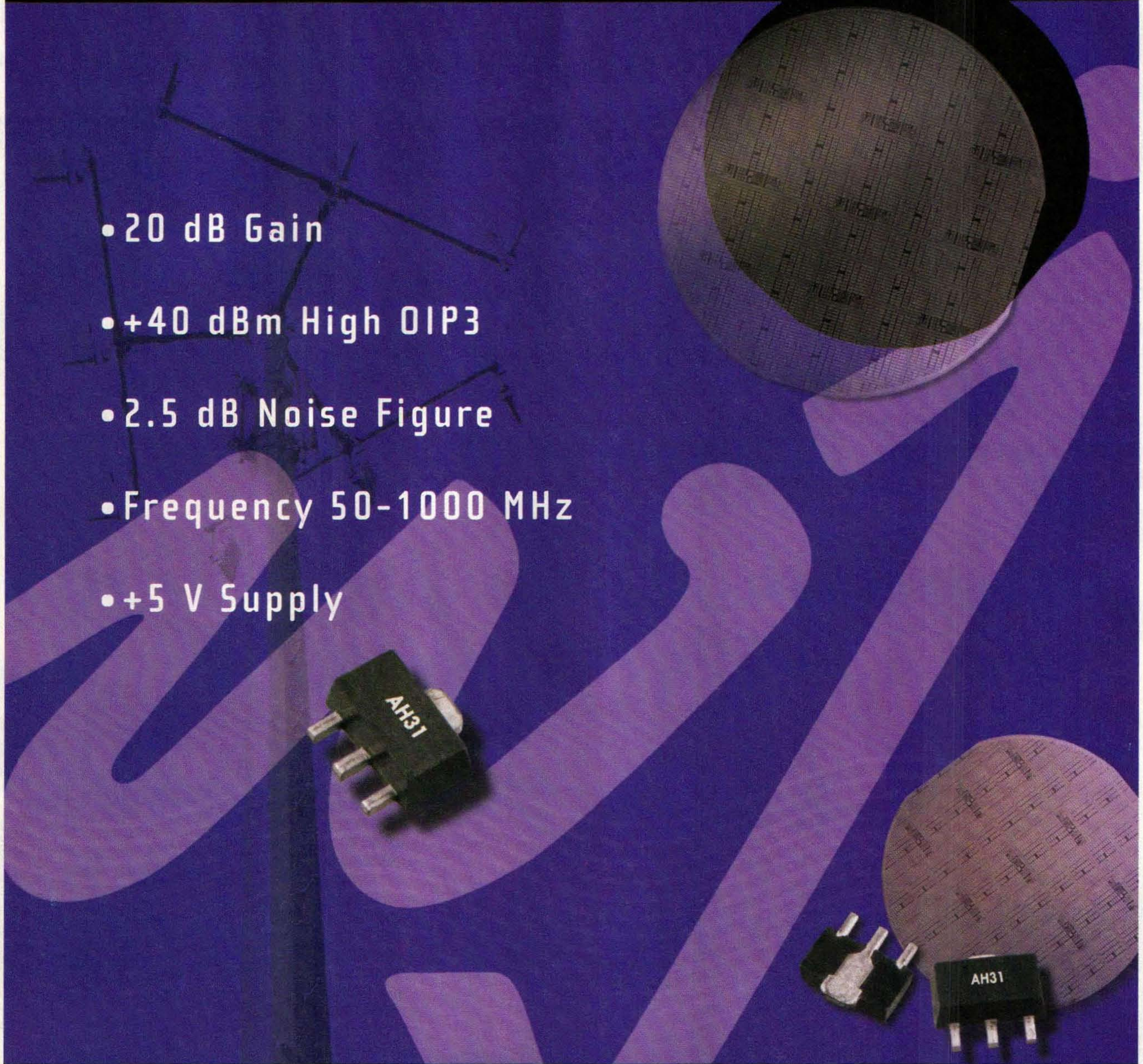

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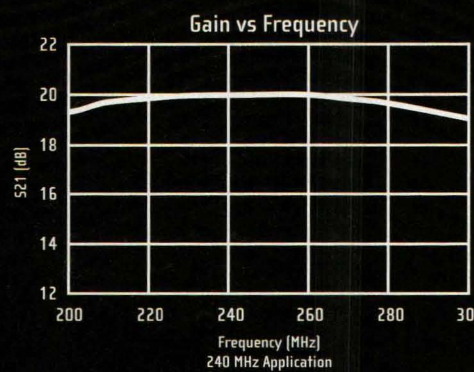

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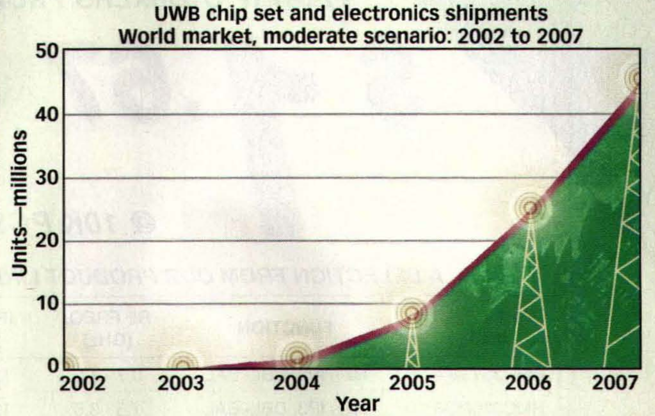
the front end

News items from the communications arena.

The UWB Community Must Standardize Technology And Their Message

OYSTER BAY, NY—A battle between entrenched wireless carriers and new supporters of ultra-wideband (UWB) technology has been unfolding recently, possibly hindering the market potential for UWB. Joining the wireless carriers are Global Positioning System (GPS) and avionics equipment makers, among others. Collectively, these companies have deep pockets and considerable power to lobby against UWB technology. A more unified front must be maintained by the UWB community to thwart these efforts for the technology to thrive.



(Source: Allied Business Intelligence, Inc.)

The spectrum that UWB travels through is and has been of concern by many in past years. The Federal Communications Commission (FCC) has been working on addressing some of these concerns. A report released by the FCC indicated that ordinary devices and appliances, including electric drills, hair dryers, and computers, have been shown to produce spurious emissions even higher than those allowed by UWB devices.

The lack of a definable standard is the single biggest shortfall to the development of a sustainable UWB market, according to a report authored by Paul Marcik, an analyst at Allied Business Intelligence (ABI). The report, "Ultra Wideband (UWB) Wireless—An Evaluation of Technology Prospects and Potential Market Applications," states that the total global shipments for UWB-enabled electronics and chip sets could reach 45.1 million units by 2007 **(see figure)**, with resulting revenues of $1.39 billion by the end of that year.

High-Speed Packages To Be Provided For RSC's DACs

SAN DIEGO, CA—StratEdge, a firm involved in the design and production of semiconductor packages for high-speed devices, has signed an agreement with Rockwell Scientific Co. LLC (RSC) to design, manufacture, and assemble the package for RSC's new RDA012 12-b digital-to-analog converter (DAC) that has a guaranteed minimum word rate of 1 GSamples/s.

The StratEdge package is a glass-wall, hermetically sealed 32-pin quad flat pack measuring 0.25 × 0.25 in. (6.4 × 6.4 mm) in size. It allows the RDA012 to provide an efficient heat-dissipation path through a metal-based substrate on the bottom of the package and maintain electrical integrity throughout its operation. StratEdge designed and manufactured the package, as well as performed the polymer die attach, automated gold (Au) wedge wire bonding, lid sealing and marking services, and final lead trim.

"This product is an important part of RSC's business plan to provide a variety of premier high-speed mixed-signal products for commercial and defense applications," commented M.J. Choe, technical manager for RSC's High Speed Mixed Signal IC's department.

The RDA012 exhibits a 65-dBc spurious-free dynamic range (SFDR) at 333-MHz (1/3 F clock) output frequency with a 1-GHz clock. Taking advantage of advanced gallium-arsenide (GaAs) technology and error-averaging techniques, the DAC achieves high linearity at a high intermediate frequency (IF), allowing the system designer to achieve a direct upconversion without using complex, expensive linear mixers.

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Complete RF Solution For Digital TV Tuners Is Offered

IRVINE, CA—In response to the Federal Communications Commission's (FCC's) recent mandate requiring digital TV tuners in new television sets within two to five years, Toshiba America Electronic Components, Inc. (TAEC) has announced the company is putting on the market a complete set of RF integrated discrete devices required for a digital-television (DTV) tuner to help enable TV manufacturers to comply with this new ruling. Developed by Toshiba Corp., these devices include varactors, field-effect transistors (FETs), dual-gate metal-oxide semiconductor FETs (MOSFETs), pin diodes, and Schottky Barrier diodes.

"We're prepared to support the industry's transition to digital TV."

Under the new FCC regulation, all but the smallest new televisions sold in the US must be able to receive digital broadcast signals by 2007. By 2004, digital tuners must be included in half of the sets with screens of 35.0 in. (88.9 cm) or larger, with other sizes phasing in throughout the five-year transition period. In addition, all TV receiving equipment, such as video-cassette recorders (VCRs) and digital-video-disk (DVD) player/recorders must be capable of receiving DTV after July 1, 2007.

"To help TV manufacturers meet this requirement, Toshiba provides a one-stop solution for RF devices," said Tom Chand, business development engineer for TAEC's RF devices. "As a leading supplier of RF discrete devices for consumer-electronics (CE) devices, with approximately 40 percent of the market for analog CE devices and 15 percent of the market for digital CE devices, we're prepared to support the industry's transition to digital TV."

Toshiba's RF solution for DTV tuners includes the discrete devices required for the low-noise-amplifier (LNA), gain-control, and mixer functions in the tuner. An Advanced Television System Committee (ATSC) digital tuner must be capable of tuning the entire very-high-frequency [VHF] (30 to 300 MHz) and ultra-high-frequency [UHF] (300 MHz to 3 GHz) broadcast bands, as well as all standard cable bands, along with Internet Relay Chat (IRC) and HRC bands.

The FCC's mandate is intended to spur the transition to DTV, which is expected to be complete in 2007. Today, television stations in many areas broadcast in conventional analog television signals and digital signals, using additional spectrum for the digital signals on loan from the FCC. More than 200 stations are already broadcasting DTV signals, reaching an estimated 70 percent of US homes. Under the FCC guidelines, once 85 percent of a broadcaster's viewing area is capable of receiving a digital signal, the broadcaster must give back its analog spectrum, which the government plans to auction for other uses, such as wireless applications. Consumers with older TVs will be able to purchase set-top boxes if they want to receive broadcasts from digital stations over analog TVs.

802.11b WLAN Solution Is Selected For Pocket PC Series

SAN JOSE, CA—Atmel Corp. has announced that the Atmel USB 802.11b design has been selected by Hewlett-Packard Co. (HP) to provide an integrated wireless-local-area-network (WLAN) solution for select models of the recently announced HP iPAQ Pocket PC h5400 series. The Atmel reference design utilizes the RF Micro Devices, Inc. (RFMD) radio front end.

Previously, WLAN solutions for the iPAQ were achieved by use of an expansion pack and a separate WLAN PCMCIA or CF card. The compact size of the Atmel/RFMD module has enabled HP to provide an integrated WLAN solution into the base iPAQ unit, which frees up expansion pack slots or eliminates a need for an expansion pack in many cases.

"Atmel is pleased to contribute the WLAN technology for integration into HP's leading-edge iPAQ Pocket PCs. Usage in this high-profile product reinforces Atmel's position as a major solutions supplier, which can provide superior complete custom and standard solutions. We feel HP's direction is a strong step in continuing the momentum in the growing deployment of 802.11b networks," offered Nick Kanopoulos, director of Atmel's Multimedia Communications Product Group.

By offering a complete WLAN design, Atmel provides customers with the ability to reduce costs, accelerate time to market, and improve key performance metrics, such as receiver (Rx) sensitivity, throughput, and range versus leading competitive solutions. Atmel offers USB, Mini-PCI, PCMCIA, Compact Flash, and Access Point reference designs developed to be a low-cost, competitive solution to meet Wi-Fi (IEEE 802.11b) specifications.

Strategic Relationship Is Agreed For Silicon Development

GREENSBORO, NC—RF Micro Devices, Inc. (RFMD), a provider of proprietary RF integrated circuits (RF ICs) for wireless-communications applications, and Jazz Semiconductor, a privately held RF and mixed-signal silicon (Si)-wafer foundry, have agreed to enter into a strategic relationship for Si manufacturing and development.

Under the agreement, RFMD will obtain a guaranteed, lower-cost source of supply for wafers fabricated using Jazz Semiconductor's manufacturing processes, including silicon germanium (SiGe), bipolar-complementary-metal-oxide semiconductor (BiCMOS), and RF CMOS. In addition, RFMD will collaborate with Jazz on the development of wireless technology roadmaps, including joint process development and the optimization of these processes for fabrication of next-generation Si RF ICs. The arrangement is expected to help RFMD develop proprietary mixed-mode Si technologies for its system-on-a-chip (SoC) integration roadmap.

"We believe this strategic relationship strengthens our competitive position as an integral part of our customers' supply chains."

The two companies also announced that RFMD has agreed to invest $60 million in Jazz for a minority equity position in the company. Jerry Neal, executive vice president for strategic development and co-founder of RFMD, will join Jazz Semiconductor's board of directors.

"Jazz is a leader in advanced SiGe BiCMOS and RF CMOS manufacturing processes with substantial, state-of-the-art silicon foundry resources," Neal stated. "We believe this strategic relationship strengthens our competitive position as an integral part of our customers' supply chains by providing us with a guaranteed source of supply for high-performance silicon manufacturing capacity. Additionally, we expect our lower cost structure will enable cost reductions across our silicon product portfolio, while facilitating expansion in new markets and generating incremental growth opportunities in current markets, such as IEEE 802.11."

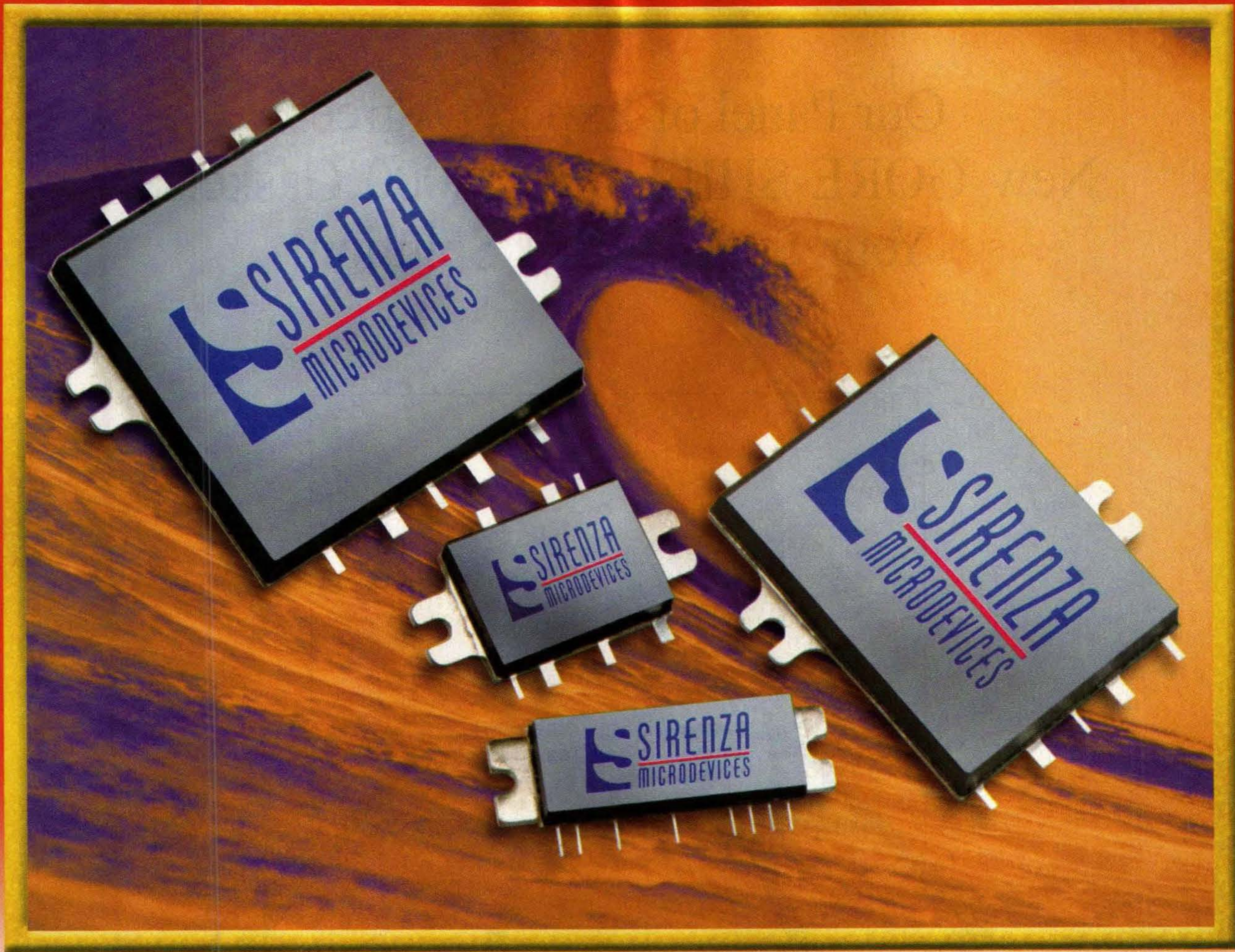
Kudos

TAMPA, FL—The Center for Wireless and Microwave Information Systems at the University of South Florida has announced MS and Ph.D. graduate fellowship awards for the 2002/2003 academic year.These fellowships are made possible by funding provided over the past several years by Mini-Circuits, TDK Electronics Ireland, Motorola, Raytheon, Harris, RF Micro Devices, Northrop Grumman, Xetron, and other companies. Charles Bayliss II (MS), Balaji Lakshimarayan (Ph.D.), Lester Lopez (Ph.D.), and Jiang Liu (Ph.D.) have been awarded Mini-Circuits Associate Fellowships. Anand Mehta (MS) has been awarded the TDK Fellowship, and Brad Rametta (Ph.D.), Christopher Trent (Ph.D.), and Alberto Rodriguez (Ph.D.) have been awarded WAMI Tuition Assistance Fellowships. The Mini-Circuits and TDK fellowships provide a generous stipend supplement to a normal RA/TA income, full tuition, and health insurance. The WAMI Tuition Assistance Fellowships, funded by contributions of multiple companies, provide a smaller stipend supplement and health insurance. The recognition and financial assistance of these fellowships has had a large impact on the quality and motivation of students pursuing wireless and microwave graduate studies at USF.

SAN DIEGO, CA—Kyocera Wireless Corp. has been awarded the 2002 High Tech Award, in the Communications Products & Services category, from the San Diego chapter of AeA, the nation's largest high-tech industry association. Kyocera was recognized for excellence in a number of areas, including technological leadership among wireless handset makers and environmentally responsible manufacturing practices. This year's awards were held on October 15 at the Hilton Torrey Pines in La Jolla, CA.

PITTSBURGH, PA—During ceremonies held in September at Pittsburgh's Carnegie Music Hall, Ansoft Corp. was given the Tech 50 award by the Pittsburgh Technology Council. The award honors the firms that are ranked as the 50 fastest-growing high-tech companies in Southwestern Pennsylvania. The firms honored have demonstrated financial growth, advancement in product development or sales, corporate citizenship, job growth/retention, and innovation.

BRISTOL, ENGLAND—Nick Long, of Great Circle Design Ltd., was presented with the "Best Paper Award" at the ARMMS RF and Microwave Society's Meeting at Tortworth Court on October 28 and 29. Long's paper, titled "Using Network Analyzers to Design Oscillators," was voted the best of all of the papers presented over the two-day conference. MRF



More Power to You

Sirenza adds integrated power modules to its comprehensive RF component line

Xemod is now part of Sirenza Microdevices. As the originator of 'plug-n-play' high-power solutions for linear power-amplifier designs, Xemod extends Sirenza's power-component product line to significantly higher power levels and operating voltages for wireless network-equipment applications.

Xemod originated the QuikPAC® line of matched modules for use as pre-drivers, drivers, and output stages in wireless power amplifiers. QuikPAC modules are offered in one- and two-stage configurations for medium-power (10–35 W) and high-power (60–200 W) applications. The module sizes are standardized so designers can easily design for multiple platforms with the same or similarly dimensioned modules.

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NEWS

SUSS's Brand Of Vermont Technology

The unlikely site of Waterbury Center, VT is home to a leading manufacturer of process and test technology and high-frequency analytical probing equipment.

JACK BROWNE
Publisher/Editor

Vermont is not normally associated with high-technology industry. But, in addition to skiing, tourism, and a famous cider mill, the tiny town of Waterbury Center, VT is also home to SUSS MicroTec, Inc., manufacturer of some of the world's most precise high-frequency manufacturing and test equipment. In spite of its location in the Green Mountain State, SUSS has assembled the right blend of about 186 people to account for almost half of the global manufacturing company's annual worldwide sales.

Electronics manufacturers know SUSS as a dependable supplier of high-quality front-end equipment, such as spin coaters, mask aligners, substrate bonders, and flip-chip bonders, as well as back-end manufacturing (test) equipment, including microwave probes and probe systems capable of measurements to 220 GHz. In fact, SUSS was ranked by VLSI Research (San Jose, CA) as one of the top 10 chip-making-equipment suppliers for 2002, placing second in wafer-processing equipment and first in test and material-handling equipment. SUSS offers mask aligners, bonders, coaters, and probers for processing wafers from 3 to 12 in. (7.62 to 30.48 cm) in diameter. Providing top-side and bottom-side capabilities, the company works extensively with manufacturers of microelectromechanical systems (MEMS) devices to supply process and test equipment suited for sensitive MEMS components.

Headquartered in Munich, Germany, SUSS boasts facilities around the globe, including four sites in Germany; three sites in the US; and sites in England, France, PRC, Japan, Thailand, and Taiwan. Within the bustling Vermont facility, many of the high-level systems are assembled and integrated; printed-circuit boards (PCBs), control electronics, and new software are developed; and customers and employees learn everything from how to operate precision equipment to complete teardown and reassembly of a wafer-probe system.

It is this approach to training—and perhaps the Vermont spirit of camaraderie—which in part accounts for the high productivity of the New England plant. The facility is a creative training ground where employees are invited to try different functions in order to develop a diversified set of skills. For formal training, the facility includes a large classroom with computers. The facility even includes on-site Guesthouses for out-of-town visitors and field personnel to stay during training.

According to Denis Place, North American General Manager for Test Systems, "we're fortunate to be located in such a beautiful setting, where we

can live in a more relaxed, rural lifestyle and still be involved in producing state-of-the-art process and test equipment for the semiconductor industry."

The Vermont facility's Building 1 was constructed in 1980, after a decision by company founders Karl, Winfried, and Ekkehard Suss to set their North American headquarters in the tiny Bavarian-like town. Since then, the space has expanded to 34,000 square feet.

Although not large by many manufacturing standards (IBM has one of their largest wafer fab facilities in near-by Burlington, VT), the SUSS plant accounts for a wide range of product lines, including a group that specializes in remanufacturing older equipment to handle new applications. The company's recently introduced microwave probe family, the |Z| Probes (developed in conjunction with the German company Rosenberger), was designed to overcome contact inconsistencies between probe and wafer/substrate common to other commercial probes. The DC-to-50-GHz microwave probe can be used with probe systems and positioners from all commercial suppliers.

Of course, the company is probably still better known for its complete probing systems. The Dresden and Waterbury Center facilities produce a wide variety of probing solutions, from cryogenic probing systems capable of handling temperatures as low as 4 K, automatic high-vacuum-controlled probe systems well suited for MEMS probing, to temperature-controlled systems with thermal chucks for at-temperature testing. The company recently introduced a compact, low-cost (about $17,000) probe station for small companies and university research laboratories.

In support of its mechanical systems, SUSS has also developed an extensive line of software tools, including the SUSS ProberBench, SussCal software, and the Vision module software. The Windows-based SUSS ProberBench provides a simple interface between the company's probe stations and commercial test instruments and third-party software products. SussCal controls a probe system and a vector network analyzer (VNA) for simple, accurate, and automated VNA calibrations. The Vision module supports automatic wafer alignment.

Being so far from a traditional technology center (such as Boston or San Jose) can often lend a sense of isolation. But on "SUSS Hill," as the company's location is known to local residents, there is an obvious sense of pride in the company and its products, and a competitive spirit not often found even in the largest technology centers. For more on SUSS MicroTec, visit the website at www.suss.com. MRF

Reference Designs Liven Wireless Show

The 11th meeting of the Wireless Systems Design Conference & Expo offers a blend of traditional technical presentations as well as a fresh look at key reference designs.

JACK BROWNE
Publisher/Editor

Wireless circuit and system designers have been developing something of a tradition in February: furthering education at the risk of romance. If this connection seems vague, it is due to the timing of the Wireless Systems Design Conference & Expo, which began life in 1993 as the Wireless Symposium & Exhibition. The conference/exhibition, one of the leading educational events for wireless design engineers, has often been scheduled for the week of Valentine's Day, much to the dismay of interested partners. Fortunately, next year's show makes allowances for romance, since it is scheduled for February 24-27, 2003 in the San Jose Convention Center (San Jose, CA).

The Wireless Systems Design Conference & Expo (www.wsdexpo.com) promises something new in its 11th year: a reference design track. Such circuits are meant to closely approximate an actual application, such as a cellular handset or a wireless-local-area-network (WLAN) hub

For example, Andy Parolin, product line manager for SiGe Semiconductor (Ottawa, Ontario, Canada) will address the importance of careful physical layouts when optimizing the performance of a reference design. Parolin will use Bluetooth and WLAN examples to demonstrate some proven optimization methods, with consideration will be given to component selection, the length and positioning of circuit traces, and methods for eliminating ground feedback.

Aditya Agarwal of Fujitsu Microelectronics America (Santa Clara, CA) will explore a reference design focused on wireless broadband metropolitan area networks, notably a design in support of interoperable systems such as IEEE 802.16a and ETSI-BRAN HIPERMAN. The report will look in detail at the OFDM physical layer (PHY) solution that is common to both IEEE 802.16a and HIPERMAN, with details about a possible system-on-a-chip (SoC) implementation and the type of reference design needed to evaluate this solution.

Bernard Olivier of California Eastern Laboratories (Santa Clara, CA) will address reference designs for embedded Global Positioning System (GPS) applications, in partnership with customer eRide. The presentations will be based on the company's low-power, highly integrated GPS receiver IC and how this receiver can be incorporated into a variety of handheld and wireless applications.

This report has been meant to provide a quick glimpse of the technical program for next year's show. Please watch for next month's issue for a more detailed preview of the technical program. MRF

VCO Spans 485 To 505 MHz

MODEL V495ME01 IS a voltage-controlled oscillator (VCO) that operates over the 485-to-505-MHz frequency range. Phase noise at 10-kHz offset is –115 dBc/Hz, while second harmonic suppression is typically –7 dBc. Tuning voltage is +0.5 to +4.5 VDC and average tuning sensitivity is 10 MHz/V. Power output is 1 ±3 dBm, while load impedance is 50 Ω. Maximum input capacitance is 150 pF and operating temperature range is –40 to +85°C. Pushing is less than 2 MHz/V and pulling is less than 2 MHz at a 14-dB return loss, any phase. Nominal supply voltage is +5 VDC, while typical supply current is 10 mA. Applications include Mobitex radios, RF modems, and satellite communications. P&A: $15.95 ea.

Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: sales@zcomm.com, Internet: www.zcomm.com

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Z-COMMUNICATIONS MODEL V495ME01

Device Offers Relay-Switch Replacements

THE FS HIGH-FREQUENCY Slide Switch is able to handle frequencies of more than 30 MHz. Suitable for wireless, communications, test, measurement, and medical industries, the switch provides an alternative solution to relay and standard switches. The unit's frequency band spans DC through 1 GHz and impedance is 75 Ω minimum. Insertion loss is 0.5 dB maximum at 1 GHz and isolation is 40 dB minimum at 1 GHz. Operating temperature range is from –25 to +70°C, and the switch is rated 0.4 VA maximum at +28 VDC AC/DC minimum. The series is available in two actuator heights, 7.4 and 12.4 mm, featuring tactile feedback and long travel of 3.5 mm.

NKK Switches, 7850 East Gelding Dr., Scottsdale, AZ 85260-3420; (480) 991-0942, FAX: (480) 998-1435, Internet: www.nkkswitches.com.

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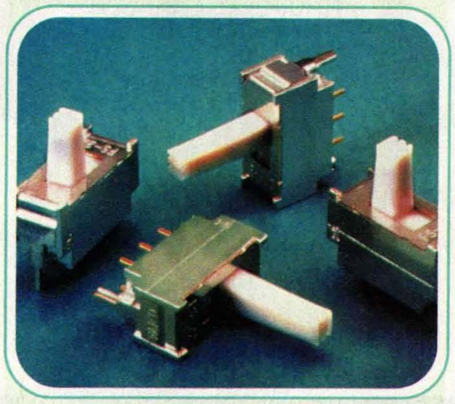

NKK SWITCHES FS HIGH-FREQUENCY SLIDE SWITCH

Antenna Boasts 14-dBi Gain

MODEL PAWES24-16 IS a customer-premises-equipment (CPE) antenna operating in the 2400-to-2483-MHz industrial-scientific-medical (ISM) frequency range. The antenna features 14-dBi antenna gain, 26 deg. of beamwidth, and is greater than 30-dB front-to-back ratio. Input return loss is –12 dB, operating temperature range is –45 to +70°C. The antenna is constructed of aluminum (Al) alloy with long-life, powder-coated light gray paint to blend with surrounding areas. Connectors are integrated, industry-standard Type-N female.

Pacific Wireless, 693 East Draper Heights Way, Suite 210, Draper, UT 84020, (801) 572-3024, FAX: (801) 572-3025, Internet: www.pacwireless.com

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PACIFIC WIRELESS MODEL PAWES24-16

Gaskets Reduce Screw Locations

GORE-SHIELD® GS8000 ELECTROMAGNETIC-INTERFERENCE (EMI) gaskets consist of a nickel (Ni)-plated base polymer backed with a thin foil layer for dimensional stability and an electrically conductive pressure-sensitive adhesive for easy installation. The gaskets' low closure force makes them suitable for flexible housing materials and enables the reduction of screw locations. Less than 3.4 N/cm of pressure for a 1-mm trace is required to compress the gaskets from a nominal starting thickness of 1 mm to a compressed thickness of 0.4 mm. At this point, DC resistance is less than 10 mΩ for a 19-mm2 donut, and shielding effectiveness is greater than 90 dB. The gaskets can accommodate a variation in the gap height of up to 0.2 mm, while maintaining low DC resistance and high shielding effectiveness.

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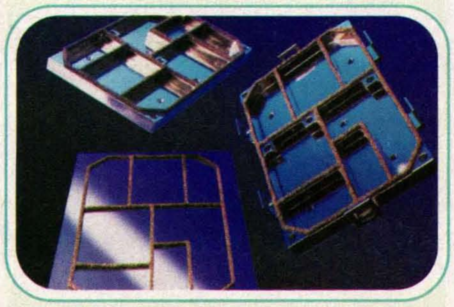

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RF MEMS Market To Top $1B By '07

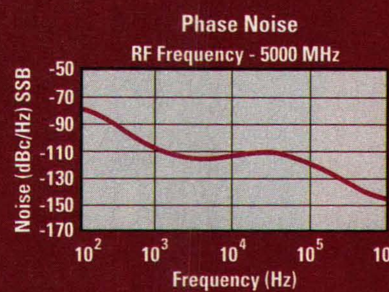
RF SYSTEMS FOR telecommunications will offer the next major opportunity for microsystems technologies, forecasts Wicht Technologie Consulting [WTC] (www.wtc-consult.de), a German-based consulting firm.

According to a new study that is being published by WTC, "The MEMS Market 2002-2007: Analysis, Forecasts & Technology Review," the market will grow rapidly over the next few years and will reach more than 2.8 billion units and a turnover of over $1 billion US in 2007. WTC forecasts that the market will be dominated by high-volume, low-price communications applications, such as mobile telephony, Global Positioning Systems (GPS), and wireless local-area networks (WLANs), while low-volume applications, including military, space, and instrumentation, will share the remainder.

"Although currently, the RF MEMS market is limited, RF MEMS components are expected to satisfy future requirements for telecommunications systems in terms of improved performance, ease of reconfiguration, and miniaturization," commented Jeremie Bouchaud, the author of the report. "In essence, the market for RF applications is expected to be the third major breakthrough for MEMS technology, following the earlier successes of disposable blood-pressure sensors and MEMS-based accelerometers for automotive airbags."

Nevertheless, certain issues must be resolved prior to RF Micro ElectroMechanical Systems (MEMS) being accepted as viable alternatives to the traditional components currently in use. "The main challenges encountered by manufacturers of RF MEMS components include price, long-term reliability, improvements in several performance characteristics, and resolving process and packaging issues," continued Bouchaud. Furthermore, the design of RF systems will require modifications in order to benefit fully from the replacement of conventional components by RF MEMS devices. However, it is expected that the main issues will be resolved in the next few years and full-scale production of the majority of components will commence in 2005. MRF

Do you really need all the Bells and Whistles?



High performance frequency synthesizers give you the performance you want without the extra cost of options you don't need.

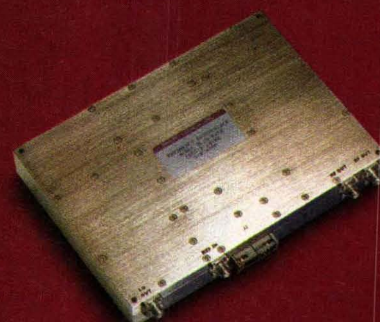
Micro Lambda Wireless, Inc. a leader in the development of next-generation YIG devices introduces a new line of high performance frequency synthesizers covering the 600 MHz to 10 GHz frequency range. Designed specifically for wide band and low noise applications, these new frequency synthesizers rival the best lab-grade test instruments on the market.

MLSW-SERIES WIDE BAND FREQUENCY SYNTHESIZERS.

This series of frequency synthesizers offers standard Multi-Octave tuning ranges covering 600 MHz to 3 GHz, 2 GHz to 8 GHz and 2 GHz to 10 GHz. Output power levels of between +10 dBm and +12 dBm are offered depending on frequency band. Frequency step size of 1 Hz is standard, but is programmable with software for customer specific requirements. External reference frequency of 10 MHz is utilized, but 5 to 50 MHz are offered as options. Excellent phase noise performance at 10 kHz offset of -110 dBc/Hz, -108 dBc/Hz and -106 dBc/Hz are provided for the 0.6 GHz to 3 GHz, 2 GHz to 8 GHz and 2 GHz to 10 GHz units respectively. The units operate from +15 Volt and +5 Volt supply lines and frequency control is via a 5-wire serial (SPI & busy) input protocol. Options include dual RF outputs and/or an L-band 2nd L.O. All units measure 5" x 7" x 1" and weigh 28 oz.

FEATURES

- 0.6 to 3.0 GHz, 2.0 to 8.0 GHz, 2.0 to 10.0 GHz Frequency Bands
- Excellent Phase Noise
- 1 Hz Step Size
- Low Profile Package
- Optional Dual RF Outputs
- Optional 2nd L.O. Output



"Look to the leader in YIG-Technology"

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CONTRACTS

EMS Technologies, Inc.—Announced an agreement with Live TV on a contract modification valued at $9.1 million for an increase in the quantity of airborne Direct Broadcast Satellite (DBS) antenna systems to be supplied by EMS. Under the modified agreement, EMS will provide continuing antenna production and warranty service for the Live TV antenna system.

Motorola's Global Telecom Solutions Sectors (GTSS)—Signed contracts totaling $446 million for the deployment of code-division-multiple-access (CDMA) 1X system for China United Telecommunications Corp. (China Unicom). The contracts are the largest awarded to any single infrastructure vendor.

Motorola, through its joint venture in Hangzhou and partners Guangzhou Jinpeng Group Co. Ltd., will provide its SC4812TTM base station to expand and upgrade China Unicom's 95A CDMA network in the city of Beijing and in 10 provinces, including Guangdong, Jiangsu, Fujian, Hebei, Jilin, Shanxi, Jiangxi, Guangxi, Xinjiang, and Gansu. With the exception of a frame contract in Beijing, final contracts for CDMA 1X deployment have been signed for the other 10 provinces. Overall, the expansion will provide additional network capacity for up to 5.4 million subscribers.

Motorola CDMA2000 1X equipment will enable operators to offer their subscribers voice and data services at speeds of up to 153 kb/s. This speed is up to 10 times faster than what is available on second-generation (2G) networks. With this increased speed, subscribers can easily download music and data directly from the Internet, enjoy multimedia, video on demand, and advanced location-based services from their mobile phones.

AT&T—Announced that it has won a multiyear contract from LoJack Corp. to provide local and long-distance services that form the core of LoJack's communications infrastructure. The three-year contract is valued at more than $2 million.

AT&T will provide all of LoJack's inbound and outbound voice services for all office locations, including call centers in Westwood, MA and Palmdale, CA.

AT&T will provide LoJack communications services through the AT&T Business Network (ABN), an integrated offer that enables mid-sized companies to easily purchase, manage, and expand a portfolio of data, Internet-access, and voice-communications services.

FRESH STARTS

Silicon Wave, Inc.—Announced that its Bluetooth radio modem, baseband processor, and protocol software have been authorized for use in testing the Bluetooth wireless capabilities of products using the Windows XP operating system. Microsoft Corp.'s announcement of native support for the Bluetooth specification in Windows XP means that hardware vendors seeking to use the 'Designed for Windows' logo for their devices enabled with Bluetooth technology must undergo compatibility testing through Microsoft's Windows Hardware Qualification Lab (WQHL). Silicon Wave's Bluetooth components provide developers with an approved standard for confirming the interoperability of their products with Windows XP.

AMCOM Communications, Inc.—Appointed Matec Electronique to be the exclusive representative for France.

Anaren Microwave, Inc.—Announced that its recently acquired Almelo, Netherlands-based subsidiary—Anaren Europe BV (formerly 5m Co.)—has returned to full-scale operation, following a fire in July 2001. The completely renovated plant features nearly $8 million in circuit-board production equipment. The plant is currently providing high-frequency, multilayer printed-circuit boards (PCBs) including metal-back heat-sink technology to Anaren's European Union (EU)-based customers, which include Thales, Allgon, M/A COM, Electromekan, and Nokia.

Chipcon Group AS—Opened a fully owned subsidiary, Chipcon, Inc., in Cupertino, CA. Chipcon is a provider of standardized and customized RF integrated circuits (RF ICs).

Sirenza Microdevices—Has completed the acquisition of Xemod, a designer and supplier of RF amplifier modules for the wireless-communication market. Xemod is the originator of 'plug-n-play' high-power solutions for linear power-amplifier (PA) designs. Xemod technology extends Sirenza's power component product line to significantly higher power levels and operating voltages for wireless network equipment applications.

Hittite Microwave Corp.—Appointed Micro Lambda LLC as a sales-representative firm to serve customers in Pennsylvania and southern New Jersey. Micro Lambda has offices in Clarksburg, NJ and Pasadena, MD.

Current Analysis—Launched Consumer Network Services, a new coverage area within the Telecom Services market, that will examine the telecommunications services that service providers are delivering to consumers and the Small Office Home Business (SOHO) market.

As a new area within Current Analysis' flagship service, CurrentCOMPETE, the Consumer Network Services module is designed to keep telecom-service companies abreast of the intense competition in the consumer market and financially leverage the analysis to their advantage. Consumer Network Services will provide coverage on new long-distance and local voice services, broadband service, bundled packages, service rollouts, innovative promotions, mergers and acquisitions, and key financial and regulatory events.

Proxim Corp.—Announced that it was the market-share leader in IEEE 802.11a wireless LAN Access Points and NICs for the first half of 2002, according to research from In-Stat/MDR. Proxim provides wireless local-area-network (WLAN) and wireless wide-area-network (WWAN) products. MRF

TINDLE

Enthone Taps Tindle For Executive GM Position

GORDON TINDLE has been named executive general manager of Enthone Ltd., United Kingdom, by Cookson Electronics PWB Materials & Chemistry. For the last two years, Tindle has led Enthone's PWB chemistry business in the UK and Ireland.

Emerson—HARRY CUNNINGHAM and JIM ZANELLO to consultative vice president of sales and engineering roles. Cunningham and Zanello formerly co-owned Thunderline-Z; They sold the business to the Fusite Division of Emerson in 2000.

GIL Technologies—DERRICK NEO to business director for Asia; formerly employed at several US circuitry companies.

Verizon Wireless—CINDY PATTERSON to vice president of enterprise data sales; formerly president for the Central Texas region.

Apropos Technology—JOHN REPKO to chief technology officer; formerly chief technology officer at eScout.

REMEC, Inc.—RON RAGLAND to president and COO; remains as chairman and CEO.

Ceramaseal—GRANT SCHRAG to product development engineer; formerly principal investigator at MDC Vacuum Products Corp.

Schema—TIM BROOKS to director of business development; formerly ran an independent wireless Internet product strategy and business development consulting firm.

RF Micro Devices, Inc.—FREDERICK J. LEONBERGER to the board of directors; remains as senior vice president and chief technology officer at JDS Uniphase Corp.

The License Exempt Alliance (LEA) of the Wireless Communications Association—L. DOUGLAS KEENEY to chairman; remains as CEO of US Wireless Online.

The American Electronics Association (AeA)—JAY GROVE to the board of directors of the SE Council; remains as senior vice president and general manager of EMS Technologies' Space & Technology Group/Atlanta.

StratEdge—RALPH NILSSON to president of the Taunton, MA Division; formerly process cell manager and product marketing manager at Alpha Industries.

MEMGen Corp.—KANG SUN, PH.D. to the position of vice president of business development; formerly vice president of business development and marketing at FlexICs.

Contec Innovations—SHAFIQ MUMANI to business development director for Europe and Africa; formerly business development manager for Europe, the Middle East, and Africa at Glenayre Electronics (UK) Ltd.

Thales Computers—JOSÉ ALMEIDA to manager of pre-sales support for the export regions, which include Asia, the Pacific, and Northern Europe; formerly employed at LynuxWorks, where he was responsible for technical support throughout the EMEA region.

ALMEIDA

MARLEY

Unitek Miyachi (UMC)—CRAIG MARLEY to director of laser systems and sales; formerly business development manager for the Axia Systems Division.

Modelithics—JERRY SCHAPPACHER to the board of directors; remains as president of J-micro Technologies. MRF

►SHORT COURSES

Converging Voice and Data Networks
January 6-7, 2003 (Morristown, NJ)
January 13-14, 2003 (Dallas, TX)
January 20-21, 2003 (Columbus, OH)
January 27-28, 2003 (Raleigh, NC)
February 3-4, 2003 (Chicago, IL)
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Voice over IP
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January 15-17, 2003 (Dallas, TX)
January 22-24, 2003 (Columbus, OH)
January 29-31, 2003 (Raleigh, NC)
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RF Wireless Engineering
January 27-31, 2003 (Atlanta, GA)
Georgia Tech
For further information, contact:
Sean Travers
Marketing Specialist, Continuing Education
Georgia Tech
613 Cherry St.
Swann Bldg., 3rd Fl.
Atlanta, GA 30332-0385
(404) 385-3541, FAX: (404) 894-7398
Internet: www.gtconted.org

Applied Technology Institute (ATI) Short Courses
Fundamentals of Radar Technology
January 28-30, 2003 (Arlington, VA)
Quality Suites
Radar Systems Design and Engineering
March 3-6, 2003 (College Park, MD)
Holiday Inn
For further information, contact:
Applied Technology Institute (ATI)
12960 Linden Church Rd.
Clarksville, MD 21029
(888) 501-2100, FAX: (410) 531-1013
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Internet: www.aticourses.com

►MEETINGS

2003 International CES
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Earls Court
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The IEEE Sarnoff Symposium on Advances in Wired and Wireless Communications
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The College of New Jersey
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Analyze A Chaotic Microwave Oscillator For FM-CSK Communications Systems

SYNCHRONIZING CHAOTIC OSCILLATORS to develop frequency-modulated chaos-shift-keying (FM-CSK) communication systems is a hot subject in the computer-aided engineering (CAE) community. Interest is high because this technique appears to be suitable for RF/microwave wireless transmission systems. Problems arise though, because the nonlinear simulation of circuits in these systems is difficult. This is due to the fact that the circuits rely heavily on the envelope modulation of a chaotic carrier. Time parameters of the RF oscillator and the envelope modulation are at odds, making classical time domain or harmonic-balance-analysis techniques inadequate. These measures cannot take the two time scales into account at the same time. A six-page article from researchers at IRCOM CNRS (Brive, France) explores this issue. See "Full Analysis of Chaotic Microwave Oscillator for Use in Frequency Modulated Chaos Shift Keying Communication System," *International Journal of RF and Microwave Computer-Aided Engineering,* Vol. 12, No. 5, September 2002, pp. 469-474.

Learn Confirmation Techniques For DSSS Wireless Optical Systems

DIRECT-SEQUENCE-SPREAD-SPECTRUM (DSSS) TECHNIQUES are popular due to their narrowband interference-rejection capabilities. In a five-page article, researchers have studied the use of confirmation techniques over a diffuse wireless optical baseband, intensity-modulated DSSS prototype that is well-suited for local-area-network (LAN) transmissions of in-house networks. The testing method employed by the authors simplifies the complexity of the emitter and receiver (Rx), while simultaneously easing the bandwidth requirements and reducing the co-channel interference without a major loss in performance. Guidelines concerning the implementation of spread-spectrum methodology over indoor optical channels is provided. See "Confirmation Techniques For Direct-Sequence Spread-Spectrum Wireless Optical Systems," *Microwave And Optical Technology Letters,* Vol. 34, No. 5, September 5, 2002, pp. 360-364.

Examine A New DLL-Based Clock Generator

ALTHOUGH A DELAY-LOCKED-LOOP (DLL)-based clock generator demands a clean reference signal, it possesses many advantages compared with conventional phase-locked-loop (PLL)-based clock generators. These advantages include a lack of jitter accumulation, fast locking time, stable loop operation, and simple installation of the loop filter. In a seven-page article, researchers from the IEEE have designed a phase detector that is equipped with reset circuitry and a new frequency multiplier that help to overcome the limited locking-range capabilities and frequency-multiplication problems of conventional DLL-based systems. Manufactured in a 0.35-μm complementary-metal-oxide-semiconductor (CMOS) process, this new DLL-based clock generator occupies 0.07 mm^2 of area and uses 42.9 mW of power. The generator operates in the frequency range of 120 MHz to 1.10 GHz and features a measured cycle-to-cycle jitter of ±7.28 ps at 1 GHz. The die-area, peak-to-peak, and root-mean-square (RMS) jitter are said to be the smallest compared to those of reported high-frequency clock multipliers. See "A Low-Power Small-Area ±7.28-ps-Jitter 1-GHz DLL-Based Clock Generator," *IEEE Journal Of Solid-State Circuits,* Vol. 37, No. 11, November 2002, pp. 1414-1420.

Discover An Algorithm That Corrects Time-Domain Phase Noise In OFDM Signals

ORTHOGONAL-FREQUENCY-DIVISION-MULTIPLEXING (OFDM) SYSTEMS, while popular for inclusion in a range of digital communication applications, are open to performance degradation due to carrier phase noise as the spacing between subcarriers reduces in size. To aid in the elimination of this problem, R.A. Casas, S.L. Biracree, and A.E. Youtz of the IEEE have authored a seven-page article that introduces an algorithm to compensate for carrier phase noise in OFDM communications systems. Through the creation of a linearized parametric model for phase noise, the authors have generated a least-squares (LS) estimate of the transmitted symbol. They present simulation results that use digitized terrestrial broadcast of digital television (DVB-T) RF signals that were created in a laboratory, as well as a DVB-T-compliant receiver (Rx) model to evaluate the effectiveness of the algorithm in practical, real-world environments. See "Time Domain Phase Noise Correction for OFDM Signals," *IEEE Transactions On Broadcasting,* Vol. 48, No. 3, September 2002, pp. 230-236.

Oscillators: A New Look At An Old Model

A variety of misconceptions about the use of modulation theory to describe high-frequency oscillator behavior must be abandoned in order to formulate new models for analyzing oscillators.

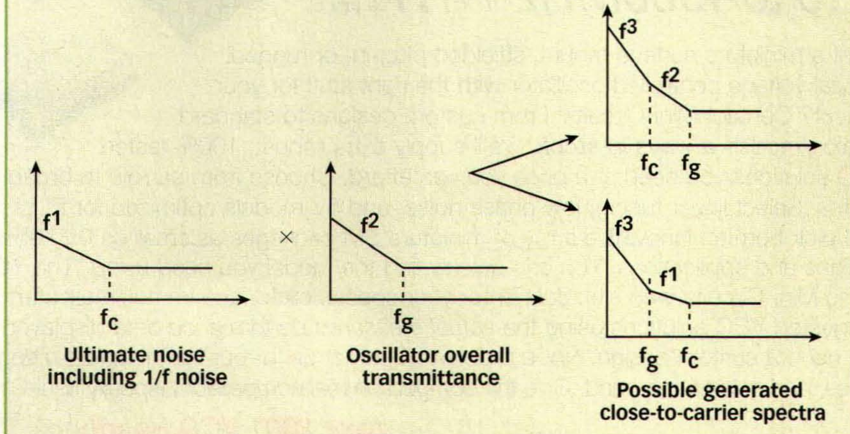
STAN ALECHNO
Rawar, Poligonowa 30, 04-051, Warsaw, Poland; FAX: (4822) 6736558, e-mail: alechno@wa.onet.pl.

Traditional models of high-frequency oscillators have guided design engineers for many years. Recently, design approaches have focused on transmission analysis, with many benefits compared to negative-resistance approaches. By adopting a "virtual-ground" design concept, it has been possible to reconfigure traditional oscillator topologies to simplify analysis,[1] and over time this approach has been supplemented with numerous reference works.[2,3, and 6] By building on fundamentals,[7] however, it may be possible to redefine the traditional models of high-frequency oscillators.

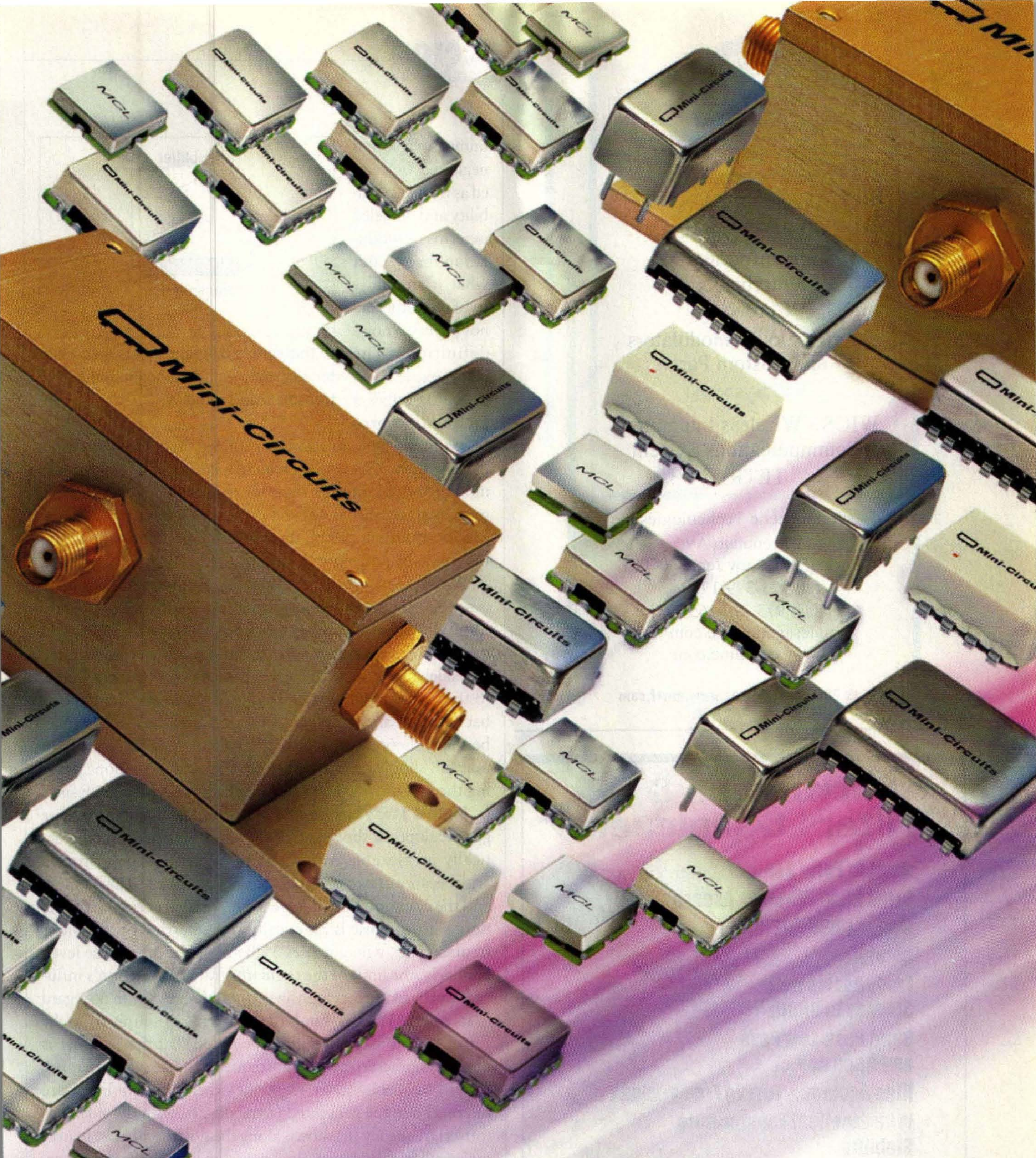
Most oscillator theory begins with a simple sine function describing an ideal waveform. In order to represent real-world noise and modulation, however, noise components must be added to the simple expression. So, the nominal amplitude, V_0, is augmented by means of amplitude noise as well as phase noise. The expression,

$$[V_0+\epsilon(t)]\sin[\omega_0 t+\varphi(t)]$$

appears at the beginning of most fundamental oscillator papers. It has been a starting point because of its twofold definition of oscillator impurities. Because of the dominance of phase noise, amplitude noise was generally treated as

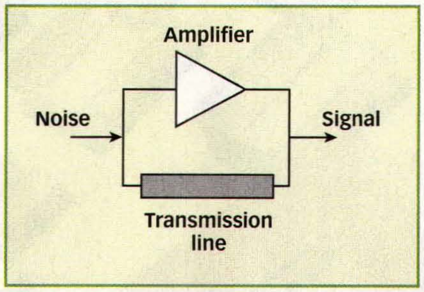


1. The possible and measurable noise components of an oscillator result from the transmission effects on initial noise sources.



Mini-Circuits
MCL

unmeasurable and neglected, or treated as frequency stability and modeled in terms of modulation theory. But what if an analysis of oscillators did not include a noise definition? The basic expression above describes a modulation process, and when modulation is examined there should be three factors: there is something which operates on one signal and modulates it by another to produce a resulting waveform. In most analysis, the modulated noise is well treated. But in the case of a pure sine wave, there is still a modulation function that must be understood.



2. This simple diagram shows an oscillator as a simple noise amplifier with transmission-line delay.

A different way to consider an oscillator model is by describing the generation of a signal. An oscillator's noise spectrum, when shown on a logarithmic plot, reveals that the power spectral density can be characterized by a power-law model. The sidebands can be depicted as descending slopes of f^{-4} close to the carrier, followed by f^{-3}, f^{-2}, f^{-1}, and the flat f^0 noise background further from the carrier. Yet, the f^{-4} slope may be more theoretical than real, and most measurements of normal, simple oscillators do not expect such a slope, leaving the f^{-2}, and f^{-1} slopes of practical interest for analysis.

Figure 1 may help to enlighten the meaning of these three generic slopes. It shows there to be only two possible and practically measurable basic oscillator spectra. These spectra arise because of two essential factors: 1/f noise (10 log/decade) and the common f^{-2} (20 log/decade) oscillator transfer function. The 1/f noise is practically characterized by its corner frequency, f_c, where it rises 3 dB above the base noise level. Similarly, the limit of the oscillator transfer function's influence can be marked as f_g on an asymptotic curve, with no regard to its origin. The two kinds of spectra result simply from the f_c to f_g relationship. It should be noted that the 1/f noise is usually characterized as low-frequency noise with reference to zero frequency (DC), while the other curves in Fig. 1 are referenced to the generated frequency, f_0, with the sideband (offset) frequency (f_s) shown along the horizontal axis. In normal oscillator modeling, upconversion of the 1/f noise is normally assumed. The influence of the 1/f noise on the oscillator noise spectra, although very important, can be regarded as a secondary effect. To simplify oscillator behavior, it is necessary to disregard 1/f noise for a while, adding it to the model as a real-world noise feature. With this assumption, any basic oscillator would generate an extremely simple signal with the close-to-carrier spectrum of 20 log/decade slope, resulting from the flat, "white noise" and f^{-2} oscillator transfer function. These conclusions are based on decades worth of noise spectra measurements, and observations rather than

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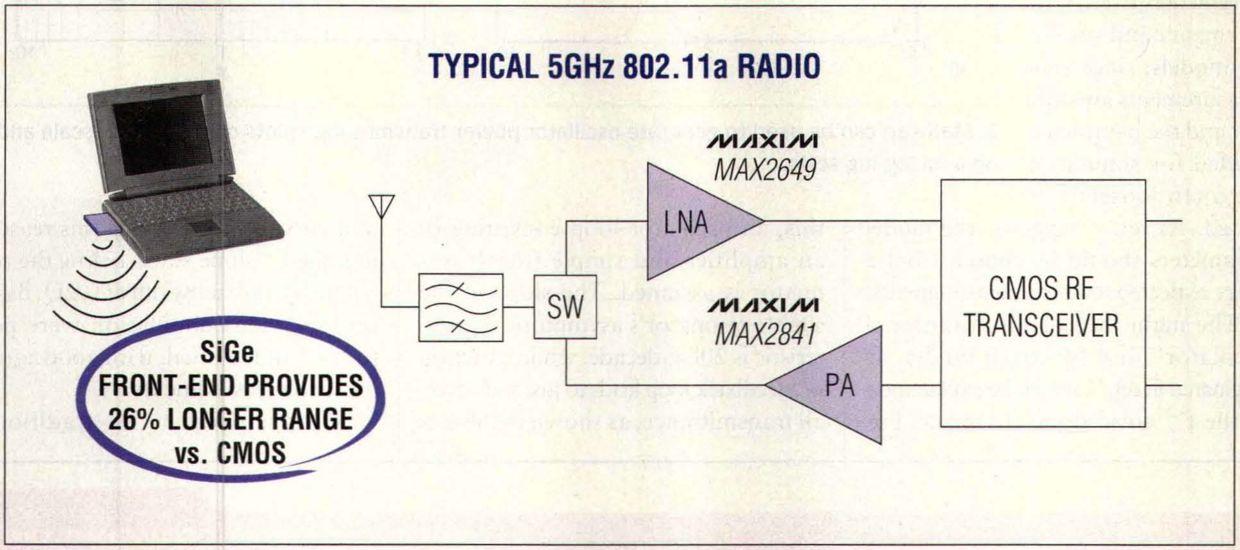

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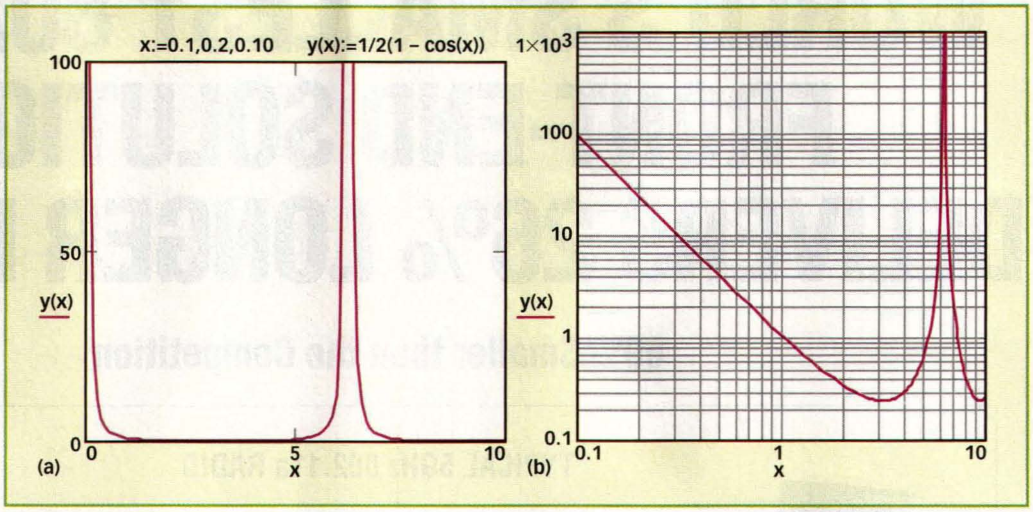
modeling. An accurate model should explain the common f^{-2} transmittance on a physical basis, and the widespread popularity of modern oscillator models seems to arise from this fact.[7]

Engineers should not be impressed with close agreement between measurements and oscillator models, since such measurements are difficult and the parameters needed for simulation are often loosely estimated. As ref. 7 suggests, the model parameters should be chosen from a range expected to fit the measurements.



3. Mathcad can be used to generate oscillator power transmittance plots on a (a) linear scale and on a (b) log-log scale.

The main idea of the traditional oscillator noise spectrum model, as originated in ref. 7, lies in the explanation of the f^{-2} noise slope character. For this, an oscillator loop consisting of an amplifier and simple (ideal) resonator is assumed. The slope of the simple resonator's asymptotic characteristic is 20log/decade, while its action in a feedback loop leads to just such overall transmittance, as shown in the second curve in Fig.1. From this reasoning, the f^{-2} slope starts below the resonator's half-bandwidth at $f_0/2Q$. Based on this, many simulation were performed and verified, with good agreement to measurements.

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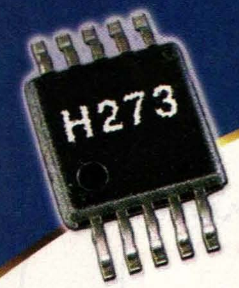

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model if the resonator is not ideal? Let the oscillation point be at its slope rather than at the top (and such dislocation is normal with phase balance condition usually set off of the optimum peak). Let the resonator be extremely asymmetric, and let it be more complex with steeper slopes. The signal close to the carrier will still be ideally symmetrical with ideal 20log/decade slope (excluding 1/f noise). But if the resonator is made less and less ideal, until its slope is flat, it would lead the theory to predict something like infinite noise. But measurements will show a clear spectrum line, not ideal, but symmetric and with an inherent 20log/decade slope.

If a microwave approach is taken to the oscillator model, then a piece of transmission line would be included in the connection from the output to the input, since every connection (at higher frequencies) must have distributed inductance as well as capacitance **(Fig. 2)**. In analytical terms, the circuit consists of a simple feedback loop with closed-loop transfer function like:

$$A_f(j\omega) = \frac{A(j\omega)}{1 - A(j\omega) \times \beta(j\omega)} \quad (1)$$

For analysis purposes, the amplifier is considered to have plain voltage transmittance, to be flat in frequency with constant phase shift, ϕ, and described by $Ae^{j\phi}$. The transmission line is assumed to be ideal, described by the delay element $\beta(j\omega = e^{-j\omega\tau})$. Oscillation will occur at the frequency ω_0 (for simplicity, the angular frequency will simply be called the frequency), where the wave transmitted through the overall loop coincides in phase, with overall phase shift of zero, described by $\phi - \omega_0\tau = 0$. It is useful to describe frequency ω as the sum of $\omega_0 + \omega_s$, where ω_s is the sideband frequency. The main product in Eq. 1 can then be written as:

SEE EQUATION 1a ON P. 60

The amplitude or loop gain, A, is needed to excite oscillation. But the real world restricts a generated waveform to a certain level, determined by the power supply and by the limitations of active

devices. In a settled state, A drops to unity. The initial value of A is essential for transient analysis, while Eq. 1 relates to the steady state (this analysis does not include nonlinear effects) with its denominator going to zero at ω_0, implying infinite closed-loop gain.

$$A(j\omega)\times\beta(j\omega) = Ae^{j\varphi}\times e^{-j(\omega_0+\omega_s)\tau} = Ae^{j(\varphi-\omega_0\tau-\omega_s\tau)} = Ae^{-j\omega_s\tau} \qquad (1a)$$

This can be understood as a possibility for any high settled signal level circulating in the loop, despite an arbitrarily low excitation, indicating that a value of A=1 should be assumed for further calculations. So far, the voltage transmittance was developed with complex functions but the transmittance of interest is the power oscillator transmittance, denoted as T_0. For this, the above designations will be set in Eq. 1, with a transition from an exponential complex form to a trigonometric form, according to the known equivalence that $e^{-j\omega\tau} = \cos\omega\tau - j\sin\omega\tau$. Next, simple transformations are needed to get the absolute value of the complex expression, and further, after squaring it, the desired overall power transmittance is derived as:

$$T_0 = \frac{1}{2(1-\cos\omega_S\tau)} \qquad (2)$$

Can this trigonometric-like function describe complex oscillators and their resultant spectrum line shapes? Plotting the function provides graphs such as **Fig. 3**(a) which shows generated spectral lines with oscillations theoretically possible at every frequency where the loop phase condition $n(2\pi)$ exists. But all real oscillators seem to have a transfer function with 20log/decade slope close to carrier, and the expression above does not appear to yield such a response. Nevertheless, if the simple trigonometric function is plotted on a log-log scale, Fig. 3(b) results, with a 20log/decade slope. This shows that the basic oscillator behavior was represented without any amplitude selectivity. The only selectivity is for phase, for phase selectivity of noise (not to be confused with traditional phase noise).

Although Fig. 3 predicts many possible oscillation frequencies, the primary phase condition will dominate all others and produce a single spectrum line (neglecting harmonics). As such, it should be possible to simplify Eq. 2 and using a trigonometric identity and the efficiency approximation of $\sin x \approx x$, a simple expression can be found:

$$T_0 = \frac{1}{4\times\sin^2(\omega_S\tau/2)} \approx \frac{1}{\omega_S^{\,2}\tau^2} \qquad (3)$$

Such a simple form clearly express-

es the fundamental oscillator behavior resulting in f^{-2} close to the carrier spectrum slope (assuming no 1/f noise) with the only required parameter being delay in the loop. Based on this form, it should be possible to build a practical circuit **(Fig. 4)**. The amplifier is simple, comprised of one or two transistors, having about 10 dB gain and phase shift of about 150 deg. typical of RF transistors. Amplifier feedback should be avoided to maintain high backward isolation and simplicity of the oscillator loop. Input/output matching should be to 50 Ω, using attenuator pads if required. A simple –6-dB resistive power divider composed of three 15-Ω resistors will maintain the loop at 50 Ω without draining excessive output power. A 0.5-m connecting cable completes the design. This simple design provides a fairly clean output spectrum, with sideband noise levels low enough to be measured only with a good spectrum analyzer, such as the HP8564E from Agilent Technologies (Santa Rosa, CA), and only at a fairly distant offset, such as 100 kHz **(Fig. 5)**.

The noise of –110 dBc/Hz at a 100-kHz offset is not much worse than performance levels of –120 to –130 dBc/Hz typical of commercial voltage-controlled oscillators (VCOs) at this frequency. The 30 dB/decade region extends to a few kHz, and for higher offset frequencies, ideally a 20 dB/decade slope exists. This is in agreement with typical bipolar-junction-transistor (BJT) devices having a corner frequency, F_c (1/f noise), on the order of 5 kHz. For comparison, the 100-kHz offset frequency lies well inside the 20log/decade region that is free of 1/f noise influence. To verify the measured results, the required expression for sideband noise, N_s, must be will determined as a function of the oscillator noise floor, N_f, multiplied by the oscillator transmittance, T_0, while referenced to generated power, P:

$$N_S = \frac{T_0 \times N_f}{P} = \frac{1}{\omega_s^2 \times \tau^2} \times \frac{kTFG}{P} \quad (4)$$

where:

k = Boltzmann's constant (1.38×10^{-23} J/K),

T = temperature (in K, at 290 K),
kT= –174 dBm/Hz,
F = amplifier thermal noise factor,
G = amplifier gain, and
P = generated power.

This expression is valid only well within the f^{-2} region.

Accounting for G in Eq. 4 requires some justification. Although G is assumed to be unity under basic oscillation conditions, it should not be treated as an ideal power follower through the band of operation. Amplifier compression at f_0 does not change the influence of G on the noise floor, expressed in terms of rising noise according to F as well as G.

Measurements of the example oscillator include risetime (τ) of approximately 3 ns, noise factor (F) of about 5 dB, gain (G) of about 10 dB, and output power (P) of about +7 dBm. At f_s = 100 kHz, these values give a result that is close to the measured value of –110 dBc/Hz. Although some of these parameters were (coarsely) estimated, the agreement between the prediction and the measurement is satisfactory.

Although not an ideal solution, the primitive oscillator circuit of Fig. 4 may be suitable for a student's laboratory. According to ref. 4, lower sideband noise will result with increased delay in the oscillator loop. A transmission line can add delay, but will add size and temperature instability. A better source of delay would include a circuit with a few LC components to provide delay independent of phase shift. The amplitude characteristics of such a circuit may not be ideally flat, although this may not be such a bad thing since this resonator circuit can help attenuate signals beyond the desired passband.

Although the traditional oscillator noise model was based upon a resonator's amplitude characteristics, neither the resonator or its amplitude selectivity is needed for a general oscillator description. Still, a variety of resonators are available for phase management, with the deepness of resonance corresponding to the amount of delay as well as the selectivity. A resonator also makes possible impedance transformations in the oscillator loop. The most prevalent resonator structure is the shunt-C coupled series type (Fig. 5b).[1] It exists in many different configurations, although only reconfigurations according to the virtual-ground concept[1] allow proper visualization of the true resonator structure.

But is the delay added by the resonator the same as group delay? Measurements of the simple circuit of **Fig. 6**(c) will yield negative values of group delay, although negative time has no meaning. By examining the three generic responses of Fig. 6, the first response

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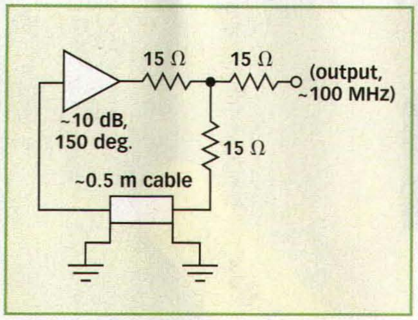
shows a strict relationship between the phase derivative and the signal-transmission time according to the definition of group delay. For the bandpass responses (Fig. 6b), this relationship can provide good approximations, but only for circuits that are not very selective, since any signal with a reasonable bandwidth and containing information will be distorted after transmission. For example, a burst carrier will have smoothed slopes at its output, so the group-delay definition cannot be easily related to this case. For circuits such as Fig. 6(c), this becomes more evident. The definition gives a function determined at an instantaneous frequency while any physical signal involves some range of frequencies, transmitted differently through a selective network. This alone suggests the lack of a direct relationship to the overall time delay. Thus, naming the phase derivative as group delay, envelope delay, or signal delay seems inadequate.

What is really needed for proper oscillator operation: the pure time delay offered by a transmission line or a high rate of phase change with respect to frequency near the oscillation point? Because an oscillator is not dealing with distributed signals (like a filter), but rather almost an instantaneous frequency, it is the second case that is desirable. Thus, the phase derivative is an important parameter in oscillator theory, and there is need for closer examination of its physical meaning. The stronger that an electromagnetic (EM) field can be made within the resonator, the more inert it will appear to an incoming wave—and this behavior is directly determined by the transmittance phase slope. A parameter called time inertia, τ_i, in units of seconds, might be useful here:

$$\tau_i = -\frac{d\varphi}{d\omega} \qquad (5)$$

An oscillator's resonator can be compared to the flywheel of a mechanical engine. In both cases, inertia ensures stability. Equation 5 can be negative or positive, denoting rotation in two directions. Note that the defined time con-

stant of EM inertia in Eq. 4 is in the second power, so its sign has no significance for generated spectra. Is there a primary direction of rotation for oscillators, as there is for motor engines? Examining one of the resonators from Fig.5(c), an obvious problem appears: near resonance, where reasonable τ_i can be obtained, there is also high attenuation. Of course, an amplifier can be added to overcome the loss. Assuming a 100-MHz oscillator in this analysis, compare resonators with good Q within 50-Ω ports. The first, which is a series resonator inserted in parallel, behaves better than the second configuration. Note that for a typical inductor Q of about 40 (at a reactance of 100 Ω), an optimum τ_i of about –50 ns results, with tolerable attenuation of 18 dB and phase angle of –40 deg. Practical resonator component values are 18 pF and 150 nH. Using the appropriate amplifier, it is possible to use a shorter cable section



4. This basic oscillator design employs 50-Ω output matching and a short length of coaxial cable for delay.

to ensure zero phase balance at the proper point on the resonator response curve.

This oscillator circuit seems to operate within a few megahertz of the expected frequency. But the resonator's phase response must be added to the model, to the phase of the transmission line, resulting in a higher oscillator frequency (shifted by the amount of the amplifier phase shift).

The resultant phase response shows three zero-crossing points, with one lower and one higher than the expected point because the gain margin is much higher at these points. Oscillation builds more quickly at these points because of the lower τ_i.

Some additional notations may be useful for oscillator close-to-the-carrier spectrum analysis (still ignoring harmonics and nonlinear behavior). In Fig. 1, frequency f_g indicated the point where oscillator transmittance begins to rise above the noise floor. According to Eq. 3, f_g will be defined by f_s when $T_0 = 1$ to $\omega_g = 1/\tau_i$ (f and $\omega = 2\pi f$) are treated without distinction here). The sideband bandwidth, B, is defined as $2f_g$, which is $1/\pi\tau_i$. With these parameters, the oscillator quality factor can be defined as:

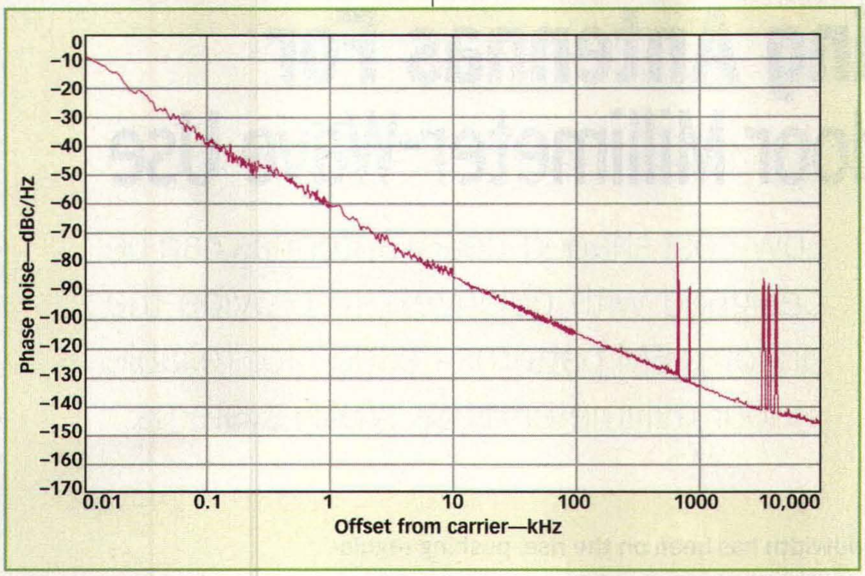
$$Q = \frac{f_0}{B} = \pi \times f_0 \times \tau_i \qquad (6)$$

This is directly related to the well-

known quality factor (Q). For a resonant tank, Eq. 6 can also be found by deriving τ_i as the phase derivative and setting Q as the quotient of the reactance to the resistance. one also obtains the result of Eq. 6. The term T_0, in terms of τ_i, appears more general, but an equivalent form in terms of Q may be more practical:

$$T_0 = \left[\frac{f_0}{f_s \times 2 \times Q}\right]^2 \qquad (7)$$

Parameter Q is of great significance, indicating circuit quality: the reactance level in reference to resistance level. Here Q refers to loaded Q (often denoted Q_L. For the same design approach and different bands, with scaling in frequency, Q remains constant while τ_i changes proportionately as well as generated sideband bandwidth and relevant sideband noise levels. MRF



5. These sideband noise measurements were made on the experimental line oscillator of Fig. 4 (an HP8662 signal generator from Agilent Technologies was used as the reference).

Editor's Note: The conclusion of this article, including Fig. 6 and the references, will be published in the January 2003 issue of *Microwaves & RF*. That installment will offer an explanation for the generation of 1/f noise in oscillators as a function of current flow through electronic materials.

Designing Antennas For Indoor Millimeter-Wave Use

Low-cost shaped-beam antennas can be designed with polarizers to provide the uniform EM patterns needed for reliable indoor millimeter-wave WLAN systems.

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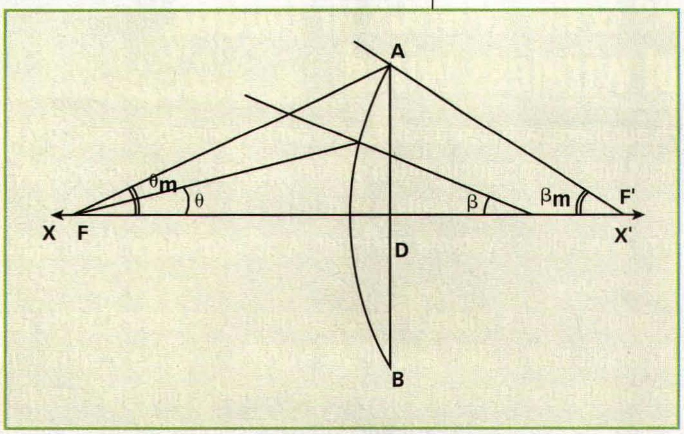
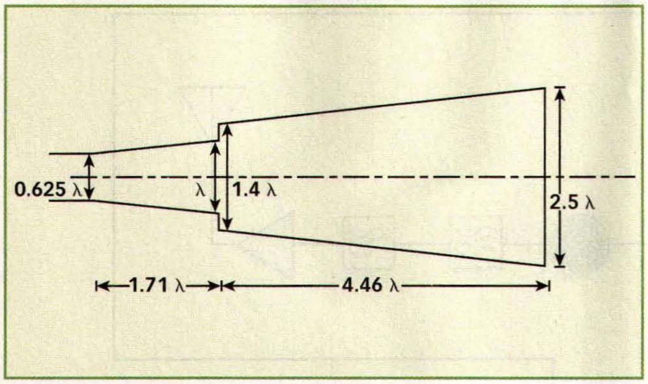
Demand for bandwidth has been on the rise, pushing regulatory agencies such as the US Federal Communications Commission (FCC) to explore the use of millimeter-wave bands for commercial applications. Already, wireless local-area networks (WLANs) have been developed for millimeter-wave frequencies. In addition, many scientists[1-3] have reported on requirements for millimeter-wave equipment for cable-television (CATV), as well as terrestrial and satellite-broadcast systems. A 60-GHz CATV system, for example, would enable the development of very compact transmitters (Txs) and receivers (Rxs), and allow a television set to receive signals anywhere in a room without wired connections. But millimeter-wave signals do not propagate well through the inner walls of buildings, requiring that each room have at least one antenna to satisfy the technical requirements of WLAN systems, for example.

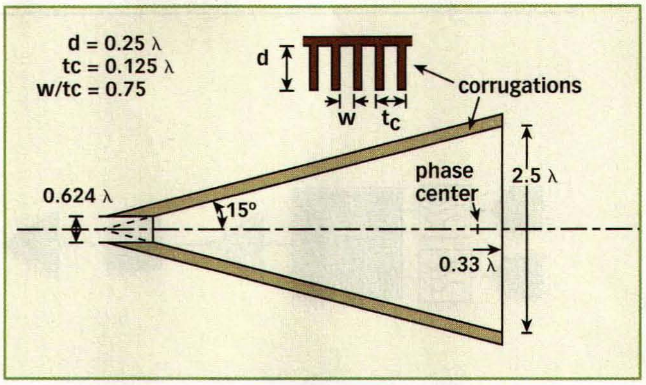
In a Notice of Proposed Rulemaking issued in June 2002,[4] the FCC signaled its intention to evaluate the potential commercial use of portions of the so-called millimeter-wave spectrum. The affected bands are 71 to 76 GHz, 81 to 86 GHz, and 92 to 95 GHz **(see table)**. This could be a boon to the deployment of high-speed WLANs and broadband-access systems for the Internet. These bands are currently restricted to government use, and are being used in radio astronomy, space-borne cloud radars, and military applications. In addition to their possible use for high-speed Internet and network access, the FCC believes that the spectrum could also



1. This antenna system is capable of producing symmetrical radiation patterns.



2. These dimensions were used to construct a dual-mode stepped waveguide horn.



3. A corrugated horn with linear circular-waveguide polarizer was also developed for operation at 62 GHz.

be used for other applications, including passive imaging of airport runways and imaging systems that could be used to display hidden contraband, weapons, and non-metal objects.

The table provides an overview of the WARC-79 and current (2002) US allocations for 71-to-76-GHz, 81-to-86-GHz, and 92-to-95-GHz bands. In the table, satellite services in the 71-to-76-GHz and 92-to-95-GHz bands are to transmit in the earth-to-space (uplink) direction and satellite services in the 81-to-86-GHz band are to transmit in the space-to-earth (downlink) direction. Portions of this spectrum are also allocated to the broadcasting, radio location, radio-astronomy service, and amateur services.

To make commercial millimeter-wave systems a reality, however, practical, inexpensive antennas are needed. What follows is a description of an inexpensive antenna configuration for indoor use to meet the requirements of millimeter-wave WLANs. The main idea of a millimeter-wave antenna with highly shaped beam pattern is based on the earlier work of Kumar.[5-7] These report and papers describe an X-band, right-hand-circularly-polarized (RHCP) shaped-beam telemetry antenna suitable for retransmitting the radar data back to an earth terminal. The antenna has been used by the European Space Agency (ESA) and Canadian Space Agency (CSA) for Earth Remote Sensing (ERS) satellites and RADARSAT, respectively. The main idea is to use a highly shaped beam-reflector antenna hanging from a room ceiling. To compensate for free-space attenuation at millimeter-wave frequencies, the reflector antenna produces a $\sec^2\theta$ type of radiation pattern in the elevation plane. The antenna provides very sharp cell (room) boundaries with negligible radiation outside the cell limits. A characteristic of $\sec^2\theta$ patterns is that the cell

To make commercial millimeter-wave systems a reality, practical, inexpensive antennas are needed.

dimensions are scaled to the antenna height. This characteristic provides a simple means to control illumination of the walls at the edge of the cell to maintain an adequate compromise between multipath effects and the need for alternative paths in case of line-of-sight blockage.

Millimeter-wave applications such as WLANs require constant electromagnetic (EM) field intensity throughout the coverage area (the room). The fixed-terminal antenna is mounted near the ceiling at the centre of the room and is required to produce $\sec^2\theta$ illumination with a square region that extends from nadir ($\theta = 0$) to (but excluding) the walls ($0 < \theta < q_{max}$). The desired $\sec^2\theta$ characteristic compensates free-space attenuation at each θ direction, producing constant electric-field illumination at constant height everywhere within the cell limits.

The design of the reflector profile is based on geometrical optics (GO) and the uniform theory of diffraction (UTD) to produce the required shaped beam. Optimization of the different parameters that define the antenna reflector has been carried out through software developed by Kumar.[5]

Figure 1 shows a symmetrical radiating system. In Fig. 1, the reflector equation is represented by R = f (θ), which is calculated by using the GO approximation. From the principle of energy conservation, it is possible to write:

SEE EQUATION 1 ON P. 70

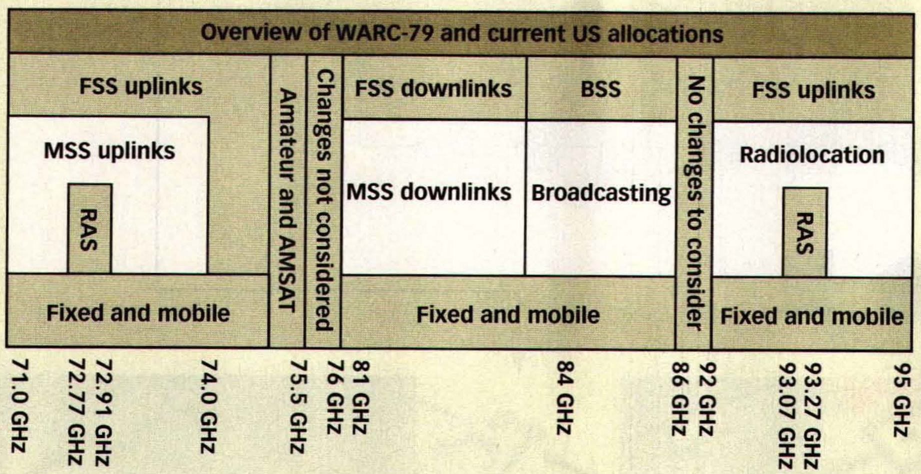
$$2\pi \int_0^{\beta} E^2{}_r(\beta)\ \sin(\beta) d\beta = 2\pi \int_0^{\theta} E^2{}_f(\theta)\ \sin(\theta)\ d\theta \quad (1)$$

$$\int_0^{\beta} I(\beta)\ \sin(\beta)\ d\beta = \int_0^{\theta} F(\theta)\ \sin(\theta)\ \mathrm{d}\theta \quad (2)$$

$$R = \mathrm{f}(\theta) \quad (3)$$

$$(1/R)(dR/d\theta) = \tan[(\theta+\beta)/2] \quad (4)$$

$$\log_e(R/R_0) = \int_0^{\theta} \tan[(\theta+\beta)/2] d\theta \quad (5)$$



This table provides an overview of US frequency allocations for 71 to 76 GHz, 81 to 86 GHz, and 92 to 95 GHz.

which can be rewritten as:

SEE EQUATION 2 ON P. 70

which is achieved by expressing the equivalence between the incident power due to the primary feed, proportional to F(θ)sinθdθ, and the reflected power, proportional to I(β)sinθdβ.

In Fig. 1, the profile of the reflector is defined as:

SEE EQUATION 3 ON P. 70

Using Snell's law to the surface of the reflector, it is possible to write:

SEE EQUATION 4 ON P. 70

which can be rewritten as:

SEE EQUATION 5 ON P. 70

where:

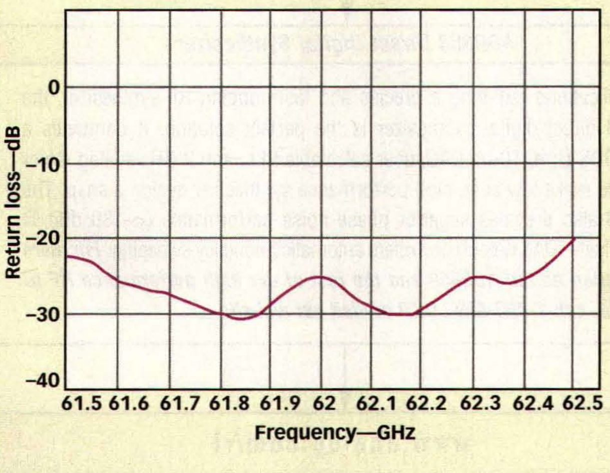
θ and β are as shown in Fig. 1. When θ = 0, R becomes R_0.

The reflector profile can be calculated from Eqs. 2 and 5, although the following parameters are required:

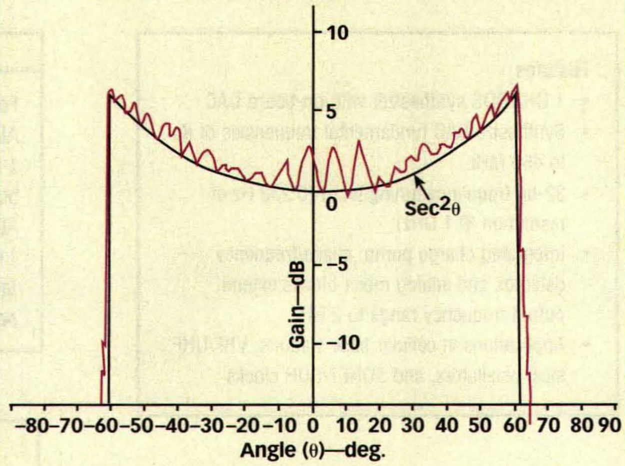
1. In Fig. 1, the angles θ_m and β_m correspond to the incident ray and reflected ray, respectively, at the edge of the reflector. The reflector diameter is denoted by D.
2. The specified antenna radiation coverage is introduced as power-normalized value I(β) for variation of β from 0 to β_m.
3. The radiation pattern of the antenna feed is defined by $E_f(\theta)$, where θ varies from 0 to θ_m.

At first, the reflector diameter is chosen and then the profile of the reflector antenna is optimized to provide the required radiation pattern. The optimization concerns the determination of the primary feed pattern, angle θm defining the reflector edge illumination, the input minimum radiation pattern, I(β), the angle β_m corresponding to the reflector edge, and the slope beyond the maximum.

Two types of feeds are considered for the reflector to produce circularly polarized radiation patterns: a dual-mode stepped horn and a corrugated horn. A stepped circular waveguide horn was designed for operation at 62 GHz to produce a TE11 + TM11 mode at its aperture. **Figure 2** shows the dimensions (in wavelength) of the dual-mode conical horn. The TE_{11} mode propagates in the circular waveguide and the TM_{11} mode is generated at the step. Both modes



4. Measurements were made of the corrugated horn's return loss at the input of the WR-19 waveguide from 61.5 to 62.5 GHz.



5. The measured radiation pattern of the millimeter-wave antenna closely follows a sec² θ curve.

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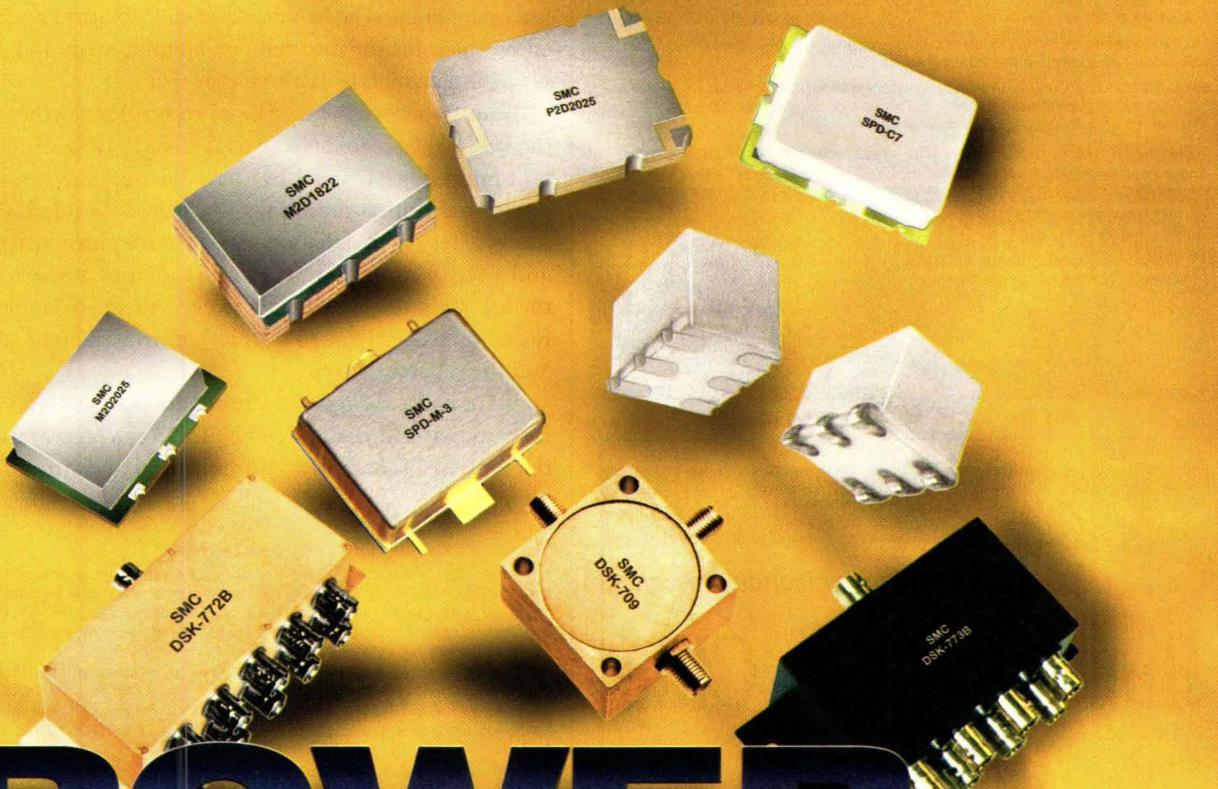

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propagate through the conical section and the superposition of the TE_{11} + TM_{11} modes take place at the aperture.

As a comparison, a corrugated horn was also designed for operation at 62 GHz **(Fig. 3)**. The horn, which is excited by a linear circular-waveguide polarizer, produces an HE_{11} mode at its aperture. The polarizer is realized through pins or dielectric fins in the circular waveguide.

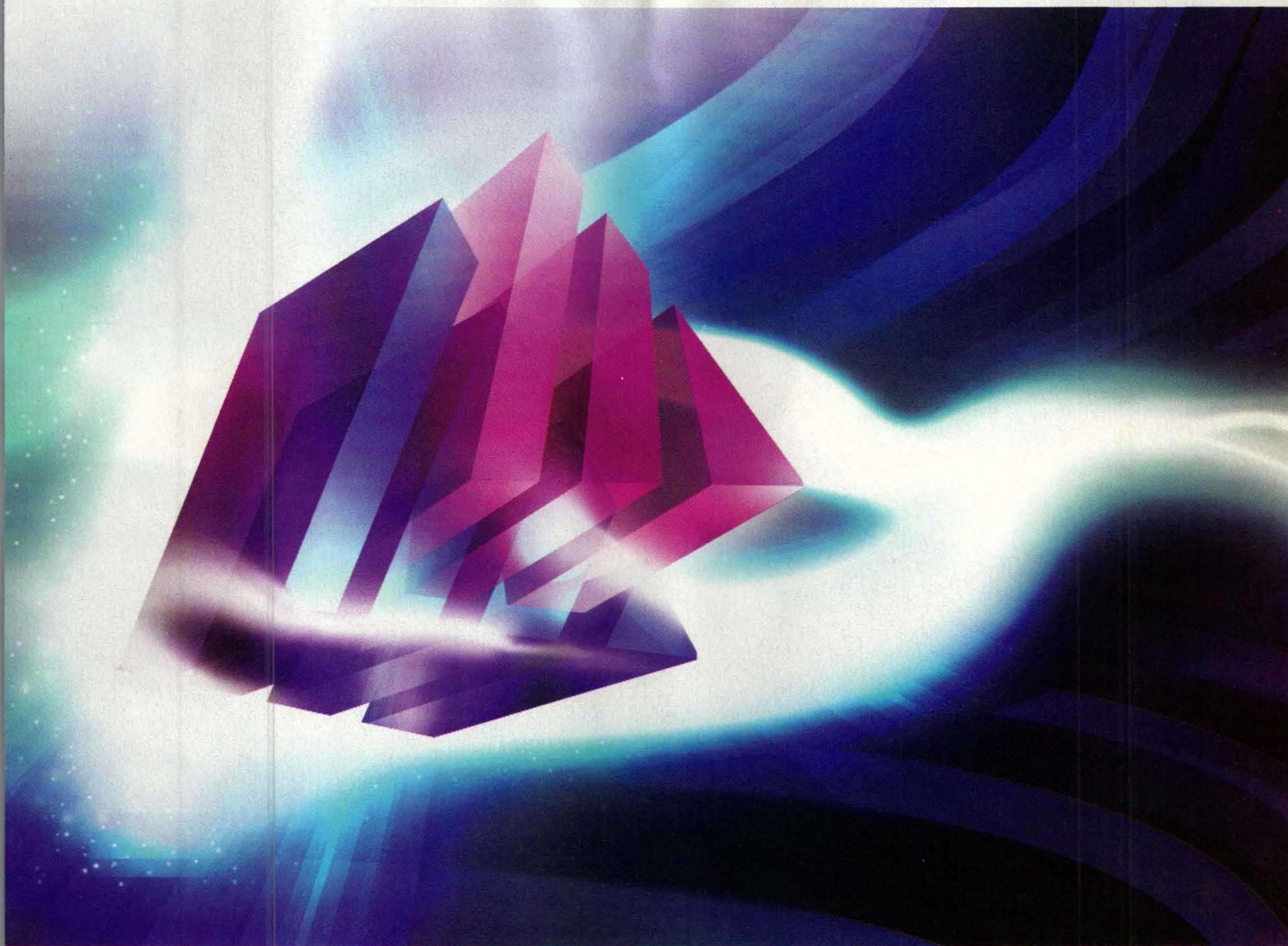
In contrast, the conical horn is lighter than the corrugated horn, with lower associated production cost. The main disadvantage of the conical horn is that it is longer than the corrugated horn, although both types of antennas have been constructed and found to meet the required specifications for millimeter-wave WLANs. In construction, a dual-mode conical or corrugated horn is attached to a polarizer and mounted on the reflector through one metallic strut and a feeder waveguide which runs along the strut.

Figure 4 shows the measured return loss at the input of the WR-19 waveguide from 61.5 to 62.5 GHz. Since antenna tuning is performed by the polarizer, the need for an additional tuning mechanism has been avoided. **Figure 5** shows a measured radiation pattern of the antenna at 62 GHz and a $\sec^2\theta$ curve. The measured radiation pattern follows the $\sec^2\theta$ curve quite well. However, there are ripples in the radiation pattern due to diffraction from the feed structure and the reflector surface.

In summary, a shaped-beam antenna can provide very uniform indoor EM patterns. This design can be very useful for the future FCC commercial-frequency bands from 71 to 95 GHz. MRF

REFERENCES

1. G. Wu., Y. Hase, and M. Inoue, "An ATM-based indoor millimetre-wave wireless LAN for multimedia transmissions," *IEICE Transactions on Communications*, Vol. E-83-B, No.8, August 2000.
2. K. Ohata, K. Maruhashi, J. Matsuda, M. Ito, W. Domon, and S. Yamazaki, "A 500-Mbps 60 GHz-band transceiver for IEEE 1394 wireless home networks," Proceedings of the 30th European Microwave Conference, Paris, France, October 2000, pp. 289-292.
3. Y. Shoji, M. Nagatsuka, K. Hamaguchi, and H. Ogawa, "60 GHz band 64QAM/OFDM terrestrial digital broadcast signal transmission by using millimetre-wave self-heterodyne system," *IEEE Transactions On Broadcasting Technology*, Vol. 47, No. 3, September 2001, pp.218-227.
4. FCC Notice of proposed rule making, FCC, Washington, DC, 20554, FCC 02-180, June 2002, pp. 1-70.
5. A. Kumar, ERS-1 X-band IDTS antenna assembly design baseline review, Spar Aerospace Ltd., Ste-Anne-de-Bellevue, Quebec, Canada, 1985.
6. A. Kumar, "Highly shaped beam telemetry antenna for the ERS-1 satellite," Proceedings IEEE Montech '86 Conference on Antennas and Communications, IEEE Cat. No. THO156-0, 1986, pp. 46-49.
7. A. Kumar, "Highly shaped beam telemetry antenna for the ERS-1 satellite," IEEE Proceedings, Vol. 134, Pt. H, No. 1, February 1987, pp. 106-108.



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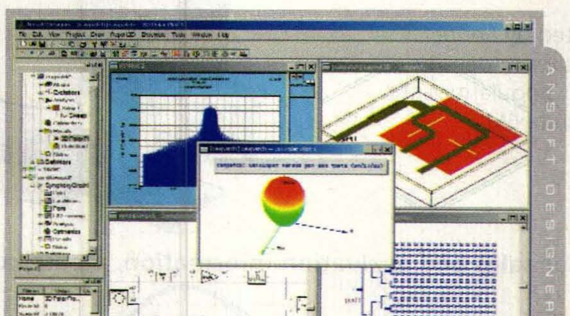

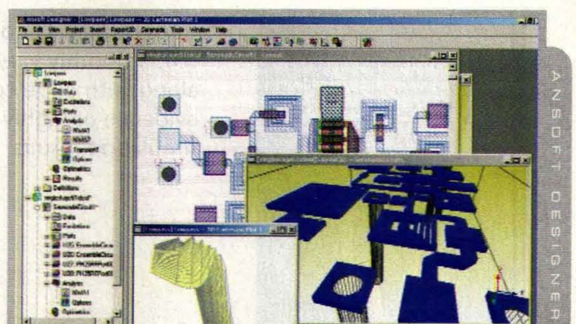

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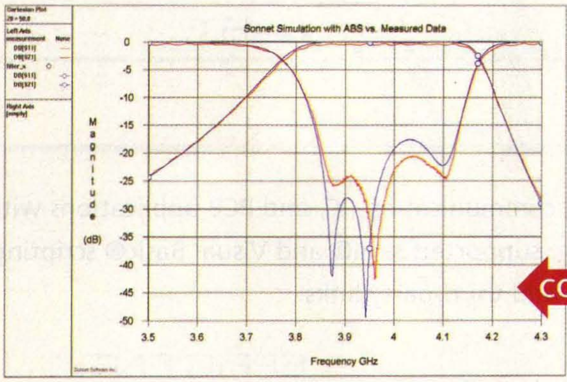
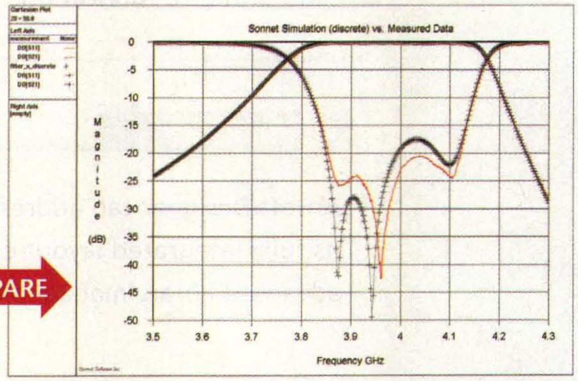
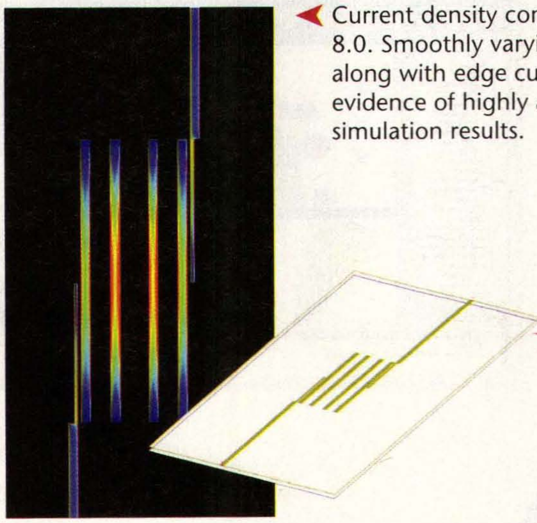


ABS simulation data based on 4 discrete EM analysis frequencies and measured data

COMPARE



300-point Discrete EM analysis and measured data



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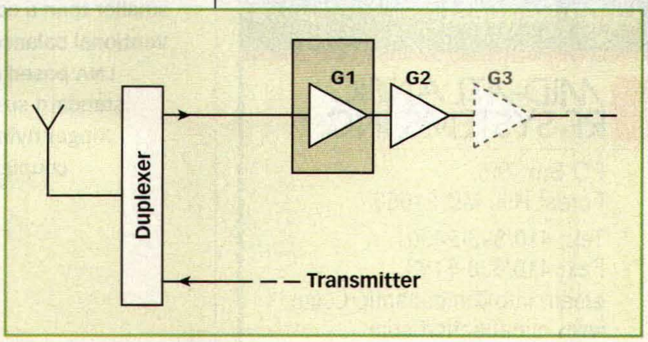
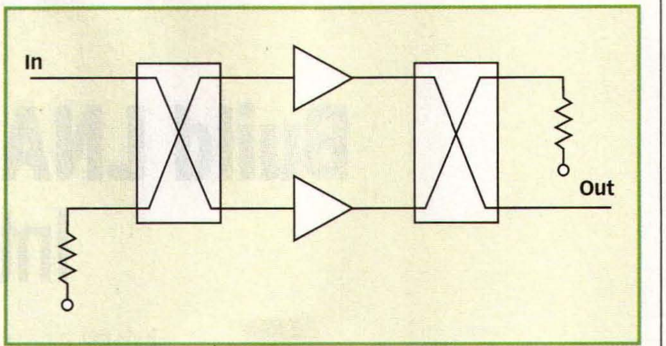
Low-noise amplifiers (LNAs) that are small and low in cost, while still maintaining noise figures of typically 0.8 dB at personal-communications-services (PCS) frequencies, are key requirements for cellular base stations. While a variety of modular and monolithic commercial LNAs are currently available, few, if any, offer the performance, size, and cost-effectiveness of a line of balanced amplifiers based on the use of integrated Xinger®-brand hybrid couplers. In addition to achieving low noise figures at low cost, the balanced configuration delivers greater dynamic range than single-ended designs with similar bandwidths and noise levels.

In communications systems, noise is often a limiting factor to received signal quality, especially at the low end of the dynamic range. High-powered transceivers can transmit signals over a distance greater than over which they can receive signals, a discrepancy known as link imbalance. This discrepancy is made worse by channel fading and multipath conditions (due to natural and man-made obstructions, such as buildings), which tend to raise the transceiver requirements for dynamic range. To improve link imbalance, high-performance duplexers and LNAs are placed close to the transceiver's antenna in the tower mast, eliminating about 3 dB of cable loss prior to the transceiver's front-end LNA and thus improving the overall system noise figure.

In a typical base-station transceiver, the first stage LNA is the most critical for setting the overall system noise figure (G1 in **Fig. 1**). To improve system noise figure, this LNA is typically located either in the tower mast close to the antenna as described above, or as a first stage in the base-station cabinet itself. The LNA portion of a base-station



1. This simplified block diagram of a cellular base station shows the position of the first-stage LNA (G1) in the gain chain.



2. A balanced LNA configuration includes two parallel stages of amplification, power division, and power combination.

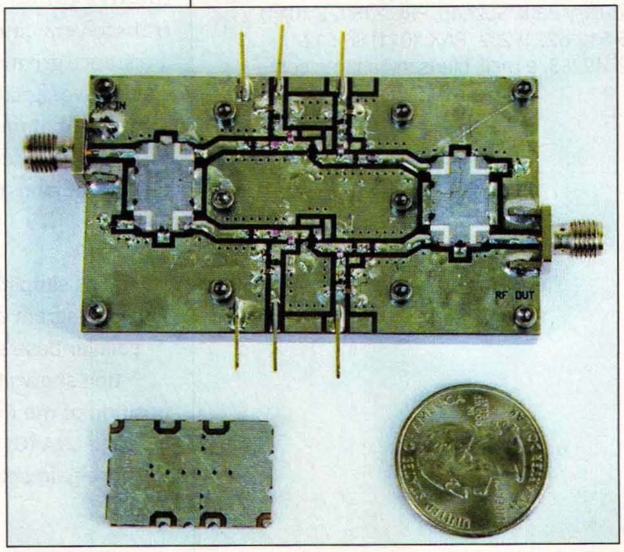
transceiver usually consists of two and sometimes three cascaded amplifier stages, depending upon the system's overall gain requirements. The first-stage amplifier, G1, sets the minimum possible noise figure for the receiver (Rx). Additional functionality is usually also implemented in the LNA circuitry, including the bypass of one or more LNAs to allow for overload or failure, as well as circuitry to compensate for gain variations with temperature and frequency. Variable attenuation is also used to set the absolute gain of the cascaded stages to a desired level of gain, due to inherent process-related performance variations in the transistors used in amplifier stages G2 and G3.

LNA applications such as for this base-station transceiver are usually implemented as balanced configuration **(Fig. 2)**, at least for the first (G1) stage. A balanced amplifier configuration has several advantages over simple, single-ended amplifiers:

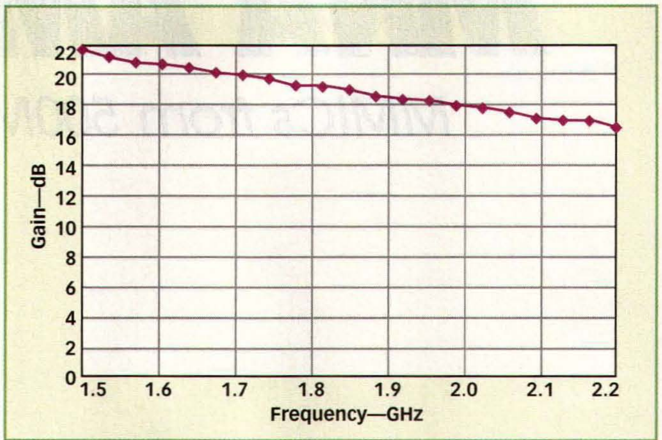
1. The intercept point is 3 dB higher than for a single stage.
2. Inherent 50-Ω input and output match due to the couplers.
3. Redundancy, which minimizes a hard failure, i.e., if one of the two amplifiers were to fail—the entire LNA will still be operational, but with degraded performance.

Ensuring Stability

A balanced amplifier configuration ensures good input and output impedance match, and helps ensure stability. However, the splitter/combiner network must exhibit low loss, since insertion loss in front of the LNA will add directly to its noise figure. In single-ended amplifiers, the input matching circuitry is usually a compromise between acceptable noise performance and acceptable return loss. The balanced configuration has an added advantage: it allows the designer to optimize the input match of the transistors for optimum noise performance—since the couplers inher-



3. The integrated LNA approach is considerably smaller than a conventional balanced LNA based on standard-sized Xinger hybrid couplers.



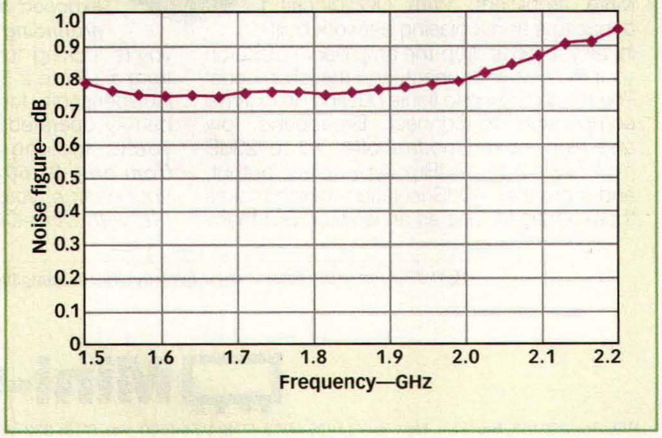
4. Preliminary gain data for the Xinger integrated LNA shows relatively flat amplitude response across a wide PCS bandwidth.

ently will ensure good return loss of the balanced stage. The noise added by the loss of the (splitter) coupler will to some extend be made up for by the reduced noise because of the optimum noise match of the transistors.

Hybrid Couplers

Traditional balanced amplifiers are implemented with printed couplers on high-quality, low-loss microstrip circuit boards. More recently, designers have been able to replace printed couplers with Xinger® surface-mount hybrid couplers, with advantages over printed couplers in size, insertion-loss performance, and repeatability. The challenge of designing a small, high-performance, low-loss coupler for the first stage is the reason that balanced amplifiers have not been integrated on either ceramic or semiconductor substrates. To achieve a high-performance coupler in a small real estate, a multilayer design approach is needed, typically as implemented in a softboard backward wave coupler, such as the Xinger® models.

Due to market demands, the company has now developed a line of Xinger® LNAs based on low-loss power splitting and combining, matching circuitry, and a pair of low-noise enhancement-mode pseudomorphic high-electron-mobility transistors (ePHEMTs). The compact layout minimizes insertion loss prior to the active devices, in the process minimizing noise figure **(Fig. 3)**. Since the pair of couplers (for the splitter and combiner) are printed on the same layer, production tolerances tend to balance, improving the overall performance. Since the entire LNA is mounted on low-loss circuit-board material within the Xinger® package, microstrip boards can be eliminated entirely for the LNA and it can be mounted on low-cost FR4 material without penalties in noise figure (assuming input connections are made directly to the LNA). This level of integration offers significant size advantages over conventional microstrip-



5. Preliminary noise-figure data for the Xinger integrated LNA Xinger®, LNA shows performance of 0.8 dB or better below 2.025 GHz.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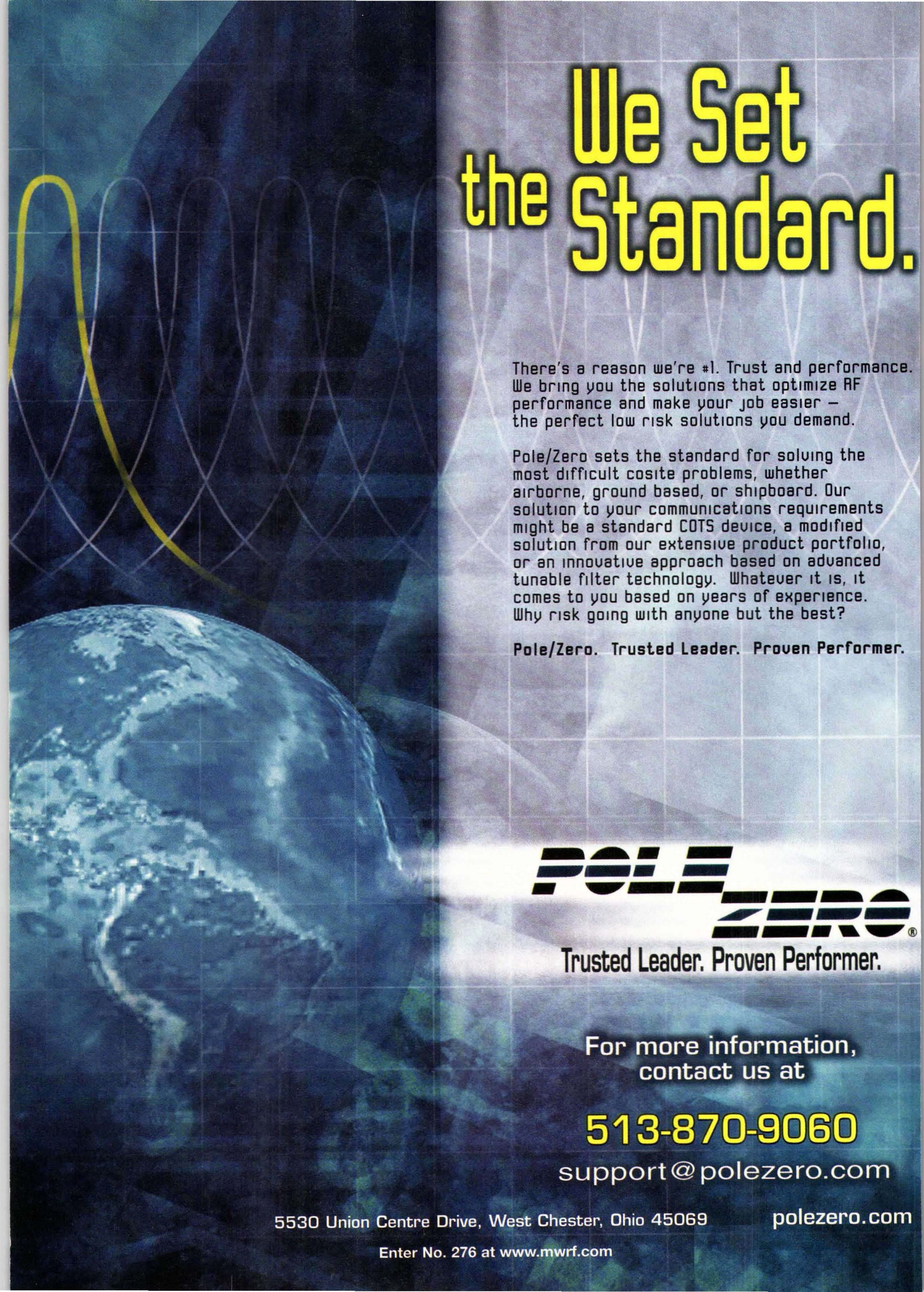
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The integrated LNAs at a glance

FREQUENCY GHz	INPUT AND OUTPUT IMPEDANCE OHMS	NOISE FIGURE dB MAX	RETURN LOSS dB MIN	GAIN dB
1.71 – 2.025	50	0.8	–20	19
3RD ORDER OUTPUT INTERCEPT POINT dBm MIN	**1-dB COMPRESSION POINT dBm MIN**	**SUPPLY VOLTAGE VOLTS**	**SUPPLY CURRENT MA MAX**	**OPERATING TEMP. °C**
32	18	+5	80	–55 to +85

based LNAs **(Fig. 4)**, even those designed with surface-mount couplers, with significant reduction in cost for low-to-medium-volume manufacturing runs compared to traditional LNA bills of materials (BOMs).

This integrated technology will be applied to a complete line of LNAs. Initial units cover 1.71 to 2.025 GHz **(see table)**, including all main communication bands from DCS (GSM1800) through the US 1900-MHz PCS band and all third-generation (3G) bands like wide-band-code-division-multiple-access (WCDMA) and IMT-2000 cellular uplink frequencies. The major advantages of these integrated LNAs for Rx designers include:

1. Integrated low-loss splitting and combining on high-performance materials within the Xinger package, allowing the rest of the Rx front end to be implemented on low-cost FR4 material.
2. Superior noise performance, with low noise figure achieved due to the compact design and the elimination of lossy transmission lines prior to the active stages.
3. A design well suited for high-volume manufacturing, ideal for use with pick-and-place machines.
4. A design that is 100-percent pretested and well suited for use by contract manufacturers.
5. Unconditional stability, with input and output ports impedance matched to 50 Ω.
6. Reduced BOM and vendor base.
7. Reduced time-to-market and minimized design issues.
8. Significant reduction in size, at 0.65 × 1 in. (1.651 × 2.54 cm), compared to conventional LNA solutions.
9. Increased reliability, with fewer solder joints.
10. Improved repeatability and standardization.
11. Ease of biasing, with single-voltage-supply operation.

In communications systems, noise is often a limiting factor to received signal quality, especially at the low end of the dynamic range.

Preliminary test results for these integrated LNAs **(Figs. 4 and 5)** reveal better than 0.8-dB noise figure in the band from 1.71 to 2.025 GHz, with about 19-dB gain and gain flatness of ±1 dB. In the individual wireless bands, the gain flatness is as good as ±0.2 dB. Preliminary specifications can be found in the table. It should be noted that these amplifiers achieve very high intercept points, due to the specific ePHEMTs used. Normally, the third-order intercept point (IP3) for an LNA is about 7 to 8 dB higher than the 1-dB compression point. In these integrated LNAs, the IP3 is typically 13 to 14 dB higher than the 1-dB compression point.

Normally, standard multilayer printed-circuit-board (PCB) production facilities are not suited for handling electrostatic-discharge (ESD) sensitive devices such as ePHEMTs inside multiple-layer packages. The harsh pro-

cesses associated with electroplating, in particular, will normally cause an issue. Due to its history in space- and defense-related manufacturing, however, Anaren's production lines are already geared for handling these devices.

One of the key design issues in the development of these integrated LNAs was the need for good grounding on the sources of the devices. More specifically, it is a well-known fact, in dealing with common-source field-effect-transistor (FET) designs, that minimizing source inductance is important to achieve good gain and stability. Using an SM package in the LNA means the ground inside the package is achieved by drilling a hole through the softboard package and plating these to contact the top and bottom of the package; additional vias must therefore be placed right next to the location of the FETs. However, to avoid crushing the embedded components, they are placed inside a cavity, as is normal practice in a multilayer package. Due to the many components needed in the matching and biasing network of the LNA, the total real estate consumed by cavities constitutes more than 50 percent, leaving little room for ground vias. If plated ground vias are to be achieved in close proximity of the FETs and the FETs are inside a cavity, these two factors constitute a challenge: How to create vias inside a cavity? This hurdle has been overcome by proprietary process in Anaren's design, and is being used in the company's new Xinger®-brand LNAs. MRF

REFERENCE

1. Ian Piper, Sid Seward, Samir Tozin, and H.P. Ostergaard, "Balanced LNA Suits Cellular Base Stations," *Microwaves & RF*, April 2002, pp. 70-80.

EDITOR'S NOTE

Anaren Microwave, Inc. recently established an operation in China that includes production, engineering, and sales functions. Known as Anaren Communications Suzhou Co. Ltd., the facility is located in Suzhou, People's Republic of China. For more information, visit the company's website at www.anaren.com.

Wireless Communications in the 21st Century

MANSOOR SHAFI, SHIGEAKI OGOSE, AND TAKESHI HATTORI, EDS.

COMMUNICATIONS TECHNOLOGY HAS experienced rapid innovation and growth over the last decade, with the move to optical networks and the new areas opened up by the Internet changing the way that people work, play, and relate to one another. These changes have made the world smaller, as communication now takes mere minutes instead of weeks. New financial and business opportunities have opened up, with home offices now replacing business offices and mobile phones allowing people to be in constant communication with each other around the clock, no matter the location. Entertainment, schooling, banking, and any number of other everyday occurrences have been revolutionized by the advances made in communications technology.

Wireless Communications in the 21st Century, edited by Mansoor Shafi, Shigeaki Ogose, and Takeshi Hattori of the IEEE, attempts to catalog these advances and explain some of the frequently asked questions concerning modern telecommunications. What are the visions that are driving wireless-communications technology forward? How are standards evolving? What kind of constituent technologies are likely to be adopted by future systems? What are the significant features of new systems currently being introduced?

Part 1 covers the visions of wireless-communications applications in the 21st century, including third-generation (3G) and fourth-generation (4G) systems, as well as wireless-packet-network evolution. Part 2 studies the developments in international communications standards, including evolving radio and network standards, Radio Access Layer standardization, and mobile Asynchronous Transfer Mode (ATM) synchronization. Part 3 details propagation issues, including multipath effects observed for the radio channel, indoor propagation modeling, propagation loss-prediction models, and path-loss measurements for wireless mobile systems.

Part 4 covers technologies, such as coding and modulation for power-constrained wireless channels, modulation and demodulation techniques for wireless communications systems, spatial temporal signal processing for broadband wireless systems, interface cancellation, multiuser detection, and fundamentals of multiple-access techniques. Part 5 details wireless systems and applications, including Enhanced Data rates for Global Evolution (EDGE), code-division multiple access (CDMA), wideband-CDMA (WCDMA) radio-access technology, and personal communications through satellite. Part 6 discusses wireless ATM networks. (2002, 441 pp., hardcover, ISBN: 0-471-15041-X, $99.95.) **John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex P019 IUD, England; (+44)1234 779777, e-mail: cs-books@wiley.co.uk, Internet: www.wiley.com.**

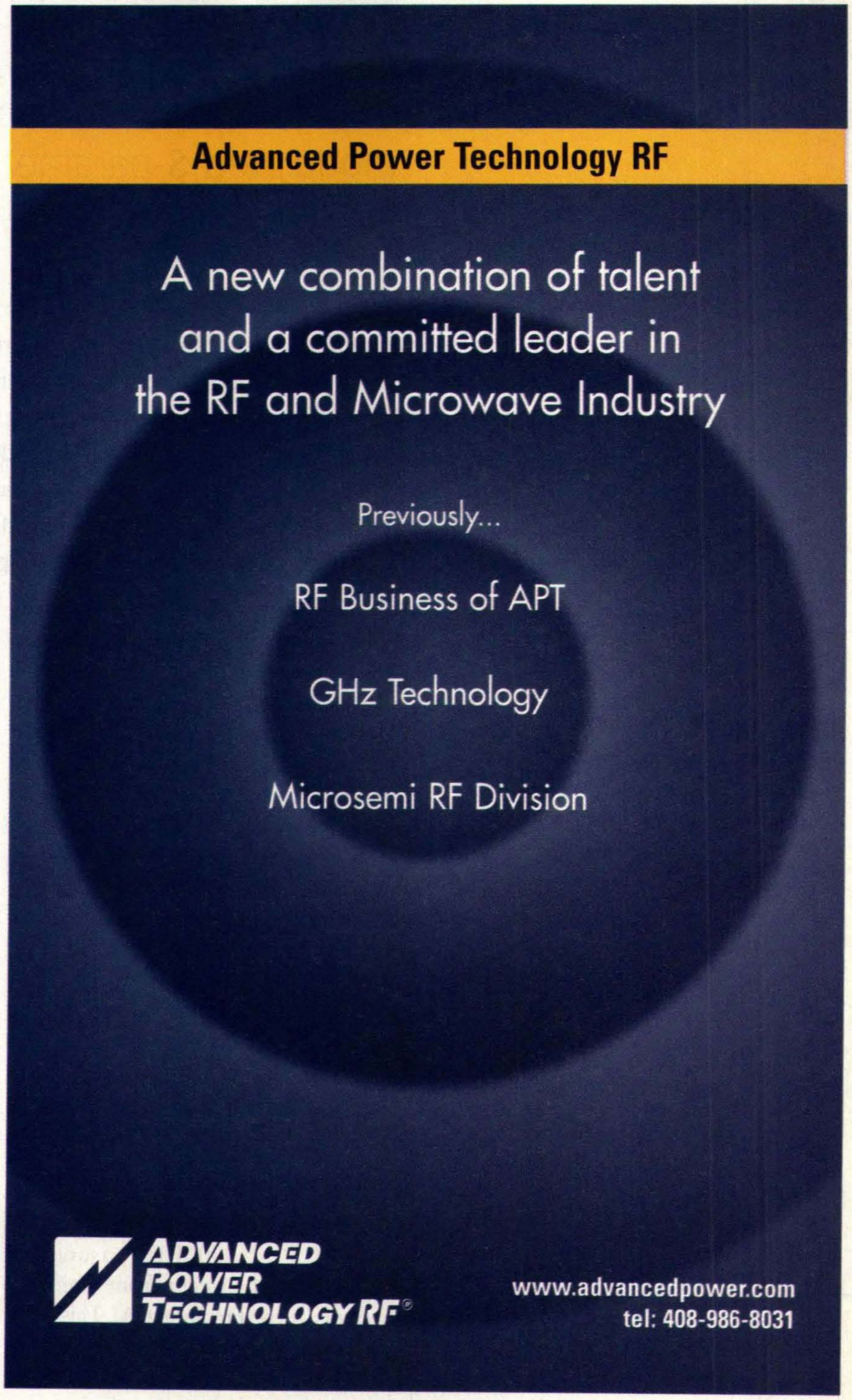
Transmissions Systems Design Handbook for Wireless Networks

HARVEY LEHPAMER

WITH THE EXPLOSION of interest in wireless networks, thanks in large part to mobile functionalities such as Universal Mobile Telecommunications System (UMTS) and the convenience of quick information access due to the Internet and e-mail, wireless providers across the globe are scrambling in an effort to reduce delivery costs in the network's most-expensive area, the local loop. Current radio technology makes it easy for providers to access subscribers quickly and deliver their telephony products and services. However, while individual operators may have separate business, regulatory, and technical drivers, many of their questions are the same. What services do the various customer bases require? Is TDMA, Global System for Mobile Communications (GSM), wideband code-division multiple access (WCDMA), or cdma2000 the best technology strategy? What is the fastest way to provide service? What programs, suppliers, and processes are required to establish a business plan? What does it take for a new provider to compete and succeed this already-crowded market?

These questions and more are answered in Harvey Lehpamer's *Transmission Design Handbook for Wireless Networks*. Lehpamer introduces the basics of wireless networks, explaining frequency-division multiple access (FDMA), TDMA, CDMA, GSM, and General Packet Radio Services (GPRS). He describes transmission network principles such as the Telecommunications Act of 1996, North American DSX-1 digital interfaces, different kinds of multiplexing, and traffic engineering. The volume takes a look at wireless-network architectures such as second-generation (2G) and 3G coexistence, transmission-network architecture, and 3G transmission networks. Theory and principles of fiber-optic transmission are explored.

Microwave point-to-point system design is covered, including basic microwave transmission theory. Transmission-network planning and design is discussed, including spectrum auctions and RF design. Transmission equipment, including AC/DC power, is explained. Transmission network deployment, testing, and commissioning are all described in detail. (2002, 615 pp., hardcover, ISBN: 1-58053-243-8, $109.00.) **Artech House, Inc., 685 Canton St., Norwood, MA 02062; (781) 769-9750, FAX: (781) 769-6334, e-mail: artech@artechhouse.com, Internet: www.artechhouse.com.**



Modulated S-Parameters Tackle Wideband Devices

A new approach to evaluating high-frequency components involving the use of modulated S-parameters can reveal a great deal about active DUTs.

Wireless communication systems continue to progress to wideband modulation formats. In particular, third-generation (3G) wireless and wireless local-area networks (WLANs) present extraordinary increases in channel bandwidth. As a result, designers are confronted with a greater divergence between the sinusoidal and modulated stimulus responses of a device. Traditional scattering (S)-parameter measurement techniques use narrowband, sinusoidal stimulus signals, resulting in the incomplete characterization of active devices. Modulated Vector Network Analysis (MVNA™) allows S-parameter measurements to be performed with complex modulated signals resulting in truer device characterization.

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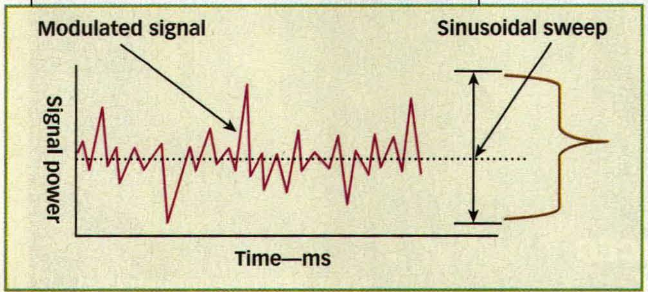
Modulated S-parameter analysis represents the first major advancement in network analysis since the introduction of the automatic vector-network analyzer (VNA) more than 30 years ago. This new capability, along with traditional wireless measurements such as adjacent-channel power ratio (ACPR), noise figure, and traditional sinusoidal S-parameters are contained in the ASL 3000RF measurement system from Credence Systems Corp. (Fremont, CA). This range of RF measurement capabilities combined with mixed-signal instrumentation creates a total wireless-device-characterization solution.



1. Drastic differences exist between the signal envelopes produced by sinusoidal and modulated vector-measurement techniques.

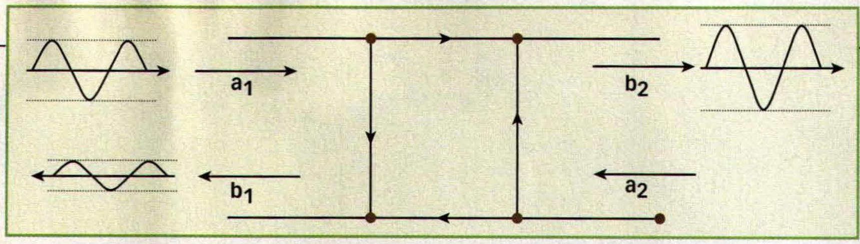
Wireless technologies are proving to hold the key for satisfying increasingly bandwidth-intense content. To meet these demands, increasingly efficient modulation techniques have been developed to deliver the high bandwidth consumers demand, while attempting to preserve the limited amount of spectrum. A consequence of these modulation formats has been an increase in channel bandwidths and nonconstant power-envelope signals. These trends have made amplifier design more difficult, particularly in light of higher linearity requirements coupling with the demand for better efficiency.

Figure 1 illustrates the dynamic signal envelope produced by various complex modulation techniques. The resulting ratio between the peak excursions and the root-mean-square (RMS) signal power is referred to as the peak-to-average ratio. These vary for different types of modulations, but generally speaking, the wider the modulation bandwidth, the higher the peak-to-average ratio. Today, WLAN systems in the form of 802.11 are taking hold in the marketplace, and wireless communication proponents are already discussing fourth-generation

(4G) systems with 100-MHz channel bandwidth. Clearly, these difficult design trends will continue. **The table** highlights peak-to-average ratios for common wireless-communication systems.

S-parameters still present a crucial starting point for active-circuit designers. While many improvements have been made in network analyzers since their widespread introduction in the early 1970s, they still rely on narrowband sinusoidal stimulus signals. S-parameters are well-understood and form the basis for a vast variety of RF and microwave devices from filters to amplifiers. But some phenomena in wideband communications are not well-described with traditional sinusoidal S-parameters.

S-parameters are essentially various ratios of incident, reflected, and transmitted power. While S-parameters can be traced back to their definitions in terms of voltage or current, the difficulty in measuring these quantities at high frequencies results in S-parameters typically being determined from power ratios, as these can be measured with great accuracy, even at microwave frequencies. **Figure 2** depicts the typical two-port device model which provides an intuitive understanding of S-parameter definitions.



2. This two-port flowgraph illustrates the basic definitions for S-parameters.

Equations 1-4 relate the two-port S-parameter ratios for the flowgraph shown in Fig. 2:

$$S_{11} = \frac{b_1}{a_1}\Big|_{a_2=0} \quad (1)$$

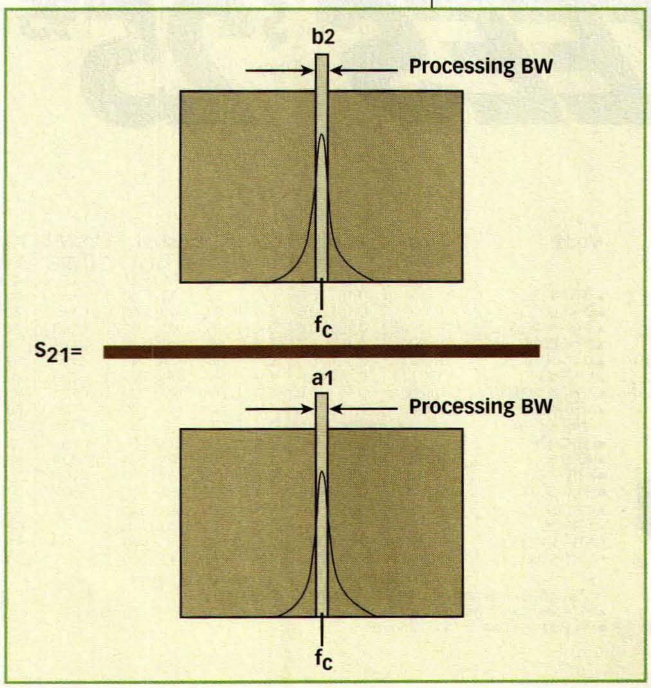
$$S_{12} = \frac{b_1}{a_2}\Big|_{a_1=0} \quad (2)$$

$$S_{21} = \frac{b_2}{a_1}\Big|_{a_2=0} \quad (3)$$

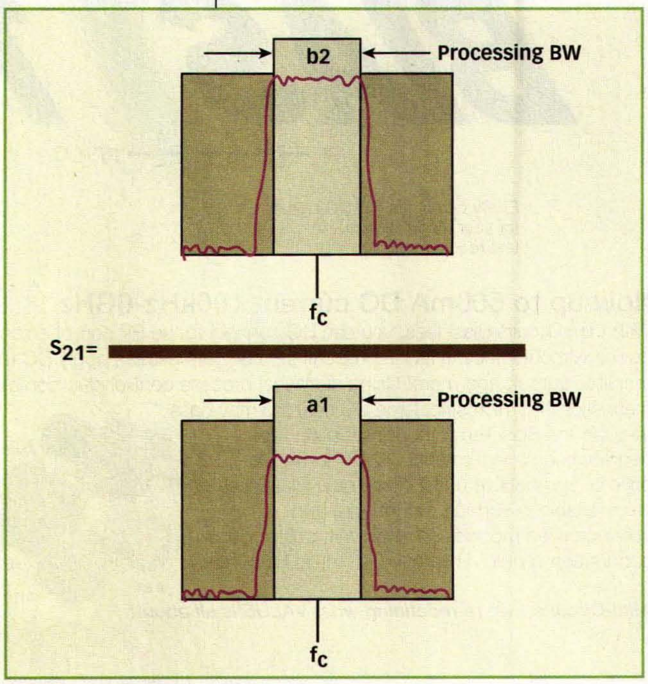
$$S_{22} = \frac{b_2}{a_2}\Big|_{a_1=0} \quad (4)$$

VNA equipment measures the a1, b1, a2, and b2 signals with narrowband receivers (Rxs) [10 Hz to 35 kHz] and then performs the required ratioing and error correction to measure S-parameters. **Figure 3** illustrates this process for the case of S_{21} (forward gain). In the case of modulated S-parameters, the basic tenets of network analysis still apply. The two-port model definition is still identical, the ratios are still defined in the same manor, but a complex modulated stimulus is applied to the device under test (DUT) rather than a single-tone sinusoid. Building on the sinusoidal example, **Fig. 4** illustrates the ratioing process for modulated S-parameters.

The ratioing process illustrated in Fig. 4 indicates that modulated S-parameters are only calculated where significant signal energy is present. In measuring S-parameters, if ratios are performed outside of the channel, i.e., where only noise exists, then the ratios will not converge. The S-parameter ratioing must be performed with the channel bandwidth in mind. For example, in the case of IS-95 [code-division multiple access (CDMA)] a processing (channel) bandwidth of 1.2288 MHz would be used. **Figure 5** demonstrates the signal-processing bandwidth approach used for modulated S-parameters.



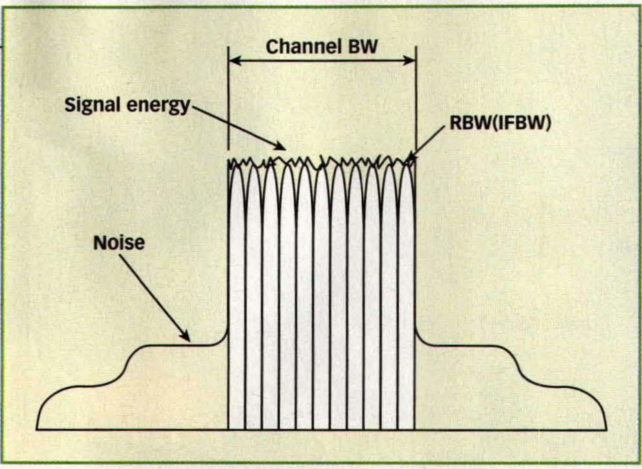
3. Sinusoidal S-parameter calculations are performed by making measurements with narrowband Rxs and performing the required ratioing and error-correction procedures..



4. Vector-network analysis for modulated S-parameters involves the use of complex modulated waveforms for evaluating a DUT.

MVNA requires a melding of traditional network-analysis hardware with high-speed digitizers and modulated-signal generation. In the ASL 3000RF MVNA, four digitizers simultaneously sample incident, reflected, and transmitted waves. High-speed 65-MSamples/s digitizers are employed to deliver up to 20 MHz of instantaneous-signal capture for wideband signals such as those encountered in IEEE 802.11 WLAN systems. To generate the modulated stimulus signal, an in-phase/quadrature (I/Q) generator allows arbitrary modulation signals to be generated from a computer file. **Figure 6** demonstrates the overall architecture.

Signal generation is achieved with a dual-channel I/Q generator which takes modulation files and generates the baseband modulation. To enable repeatable testing, it is important to consider the effects of triggering. An advanced triggering scheme allows triggers to be generated from a particular address in the modulation file. The data can then be looped repeatedly to ensure that the same portion of the waveform is used to stimulate the device. This becomes crucial when the effects of peaks and nulls in the modulated waveform are considered in light of the amplifier's response.

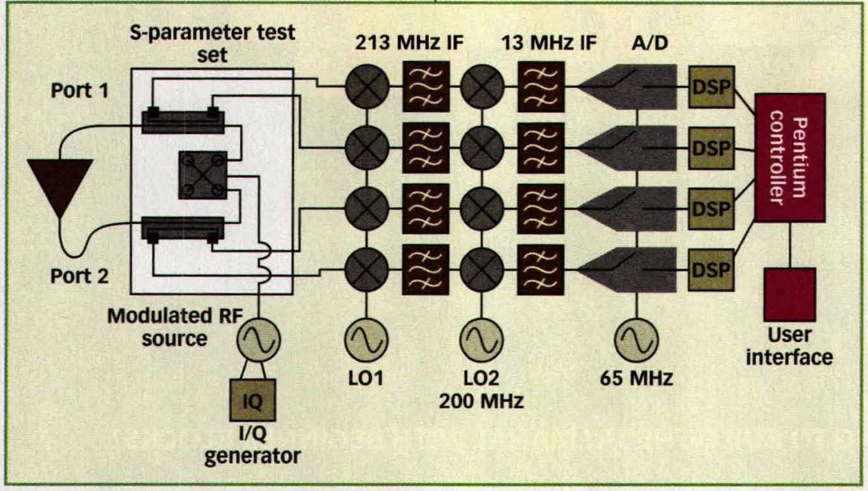


5. Specific bandwidths are used when making vector-network measurements with modulated waveforms.

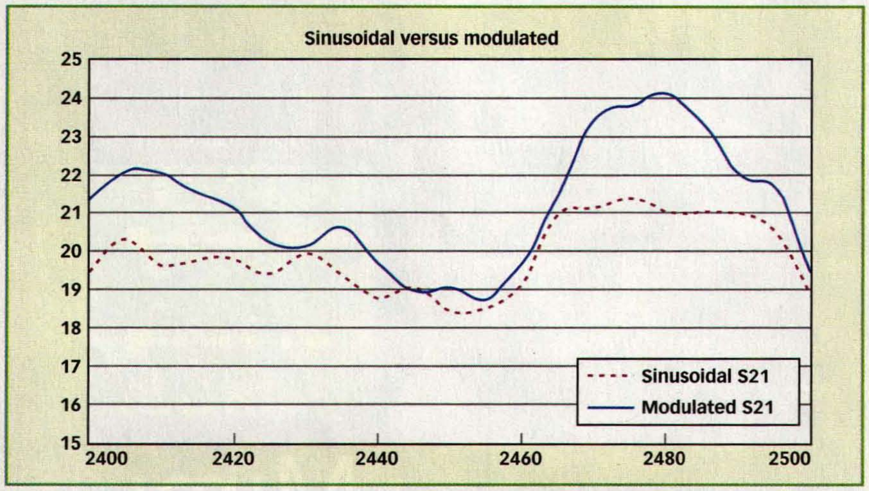
The reflectometer test set forms the front end of the test system and is of a traditional network-analyzer architecture, which supports simultaneous sampling of incident, reflected, and transmitted waves. It is critical to preserve this characteristic as S-parameters depend on the simultaneity of measurements to ensure accurate phase information. Following signal separation, the first stage of downconversion reduces signal frequency to a 213-MHz center frequency with a 20-MHz bandwidth. An external synthesizer is used to generate the first local oscillator (LO). After additional signal conditioning, the signal is mixed with a 200-MHz fixed LO down to a 13 MHz final intermediate frequency (IF).

Care must be taken in final filtering to ensure that phase response in the antialiasing filters is smooth and reasonably linear. Filters with extremely sharp rolloff (i.e., elliptic filters) can provide greater bandwidth, but with vast amounts of phase deviation. Calibration techniques can aid in removing these effects, but any small deviations in the circuit after calibration can cause wide response variations in the calibration. Sampling is performed at 65 MHz, followed by digital-signal processors (DSPs). All the Rxs are clocked from the same sample clock through a distribution scheme that ensures simultaneous acquisition.

Following acquisition of the data in the time domain, data processing is performed to calculate the S-parameters. The acquired waveforms are converted to the frequency domain using a Fast Fourier Transform (FFT) with an appropriate windowing function. To perform 12-term vector-error correction, data must be taken from the forward and reverse stimulus directions as error-cor-



6. This high-level architecture shows the four Rxs of the modulated VNA system.



7. A comparison for measurements of a WLAN PA shows differences between sinusoidal and modulated S-parameter measurements.

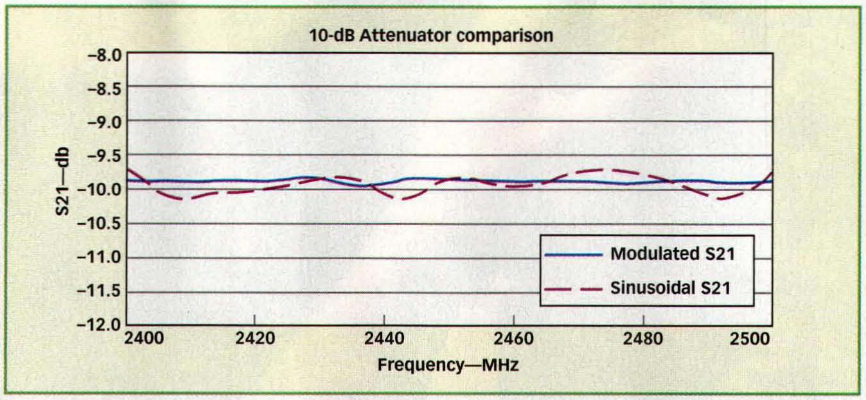
Peak-to-average ratios for common communication systems

COMMUNICATION STD.	MODULATION METHOD	PEAK-TO-AVERAGE RATIO
AMPS	FM	0
TDMA	Pi/4 DQPSK	3.5 dB
CDMA	QPSK/DSSS	10 to 12 dB
WCDMA	QPSK/DSSS	8 to 9 dB
802.11	OFDM/64 QAM	7 to 16 dB

rection equations take into account terms from either direction. The raw (acquired) frequency-domain data is then ratioed based on the standard definitions of S-parameters. Finally, error-correction equations are applied to remove fixture and other nonideal effects. Data was collected from a 2.4-GHz WLAN power amplifier (PA) using the aforementioned measurement system. In the following measurements, a quadrature-phase-shift-keying (QPSK)-modulated signal was applied to the device at various power levels demonstrating the different performance obtained for modulated versus sinusoidal conditions.

The S_{21} data for this WLAN PA demonstrates a noticeable performance difference for this device operating at a 0-dBm power-input level **(Fig. 7)**. This device is designed to provide a +20-dBm output level for various WLAN systems to provide enhanced mobility resulting from a stronger signal which, in turn, delivers a lower bit-error rate (BER). For this scenario, the 1- to 2-dB performance delta could easily be the difference between the part passing a performance test in the modulated case versus failing the test in a sinusoidal test. This critical difference could easily improve test yields, while still ensuring that the end user still obtains a high-quality device.

To ensure the accuracy of the measurement system, a passive device (a 10-dB attenuator) was tested. A passive device such as an attenuator should not exhibit the nonlinear effects that afflict active devices such as gate heating and current crowding. This is thought to be the primary mechanism for the differing behavior between modulated and sinusoidal S-parameters. **Figure 8** demonstrates good agreement between sinusoidal and modulated stimulus using a passive device. The agreement between the attenuator value is within ±0.25 dB, which demonstrates very good agreement between the various measurement approaches. This indicates that differences measured on the PA were certainly due to unique device-behavior regimes.

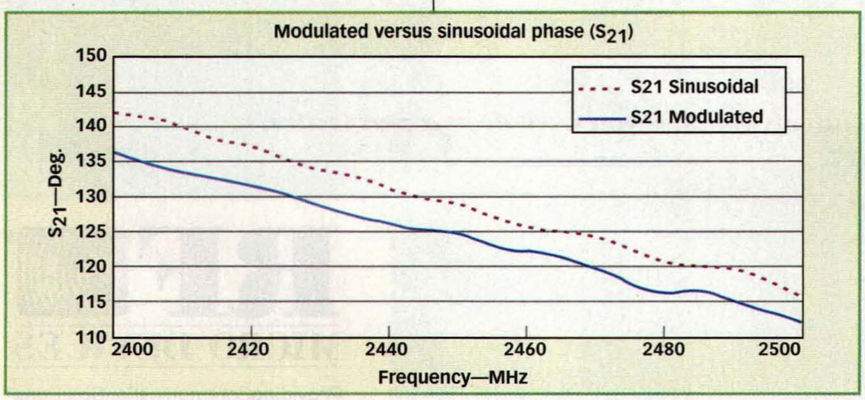


8. As expected, good agreement was achieved between sinusoidal and modulated S-parameter measurements on a 10-dB attenuator.

Measuring $<S_{21}$ yields even more information about the behavior of this amplifier under modulated stimulus **(Fig. 9)**. This is particularly useful for designs, which attempt to use phase correction methods for linearization. To date, much work has been performed in obtaining accurate amplitude-modulation/phase-modulation (AM/PM) transfer characteristics and translating them into efficient predistortion algorithms for DSP-based linearization applications. Much consternation has been expressed at the difficulty in obtaining these characteristics accurately using traditional test equipment. Traditional network analyzers do a nice job of obtaining AM/PM characteristics with sinusoidal signals, but offer no help with modulated signals. Figure 8 illustrates the differing phase response obtained for modulated and sinusoidal cases.

The results between the modulated and sinusoidal stimulus vary by up to 5 deg. This could easily mean the difference between a design passing its specifications or not. Also, a few degree changes in phase can result in a degradation in intermodulation (IM) levels of 10 dB or more. The aforementioned behavior is not exhibited with passive devices such as attenuators, as they do not exhibit the nonlinear effects inherent in transistor devices.

Credence's ASL 3000RF brings powerful new techniques to wireless device characterization and test. Modulated S-parameters provide new insight into device performance and support test conditions with "real world" complex modulated signals. This analysis methodology combines well-understood network analysis techniques with modulated signal capabilities to make S-parameters even more useful for testing today's wideband-communication systems. MRF



9. An evaluation of $<S_{21}$ measurements were made under modulated and sinusoidal stimulus.

Learn why GaAs is better than Si when designing cell-phone PAs

GALLIUM-ARSENIDE (GaAs) has replaced silicon (Si) in cellular-telephone power-amplifier (PA) applications as the technology to choose for optimized performance. GaAs technology provides lower noise figures, higher cutoff frequencies, and higher power-added efficiency (PAE) to ensure that the cellular client has expanded talk time, as opposed to PAs that use Si. This is because the GaAs PA is capable of radiating RF energy through a duplexer to the client's antenna port. The cellular standard and the power class of the client's cellphone are factors that cause different power levels to be required of GaAS PAs. As an example, a Class III Advanced Mobile Phone Service (AMPS) cellphone must radiate a power-level of no less than +28 dBm through the antenna. A code-division-multiple-access (CDMA) Class III unit, meanwhile, has a power-level requirement minimum of +23 dBm, +5 dBm less than the AMPS cellphone. Because the GaAs PA needs to meet multiple industry-standard power requirements, the RF losses in the duplexer is a crucial factor in the amplifier's design.

In a five-page application note entitled, "Using the TC1142 for Biasing a GaAs Power Amplifier," author Patrick Maresca of Microchip Technology, Inc. (Chandler, AZ) highlights a charge-pump DC-to-DC converter known as model TC1142 that uses pulse-frequency-modulation (PFM) control to produce a regulated output voltage that does not require the use a post-linear regulator. The unit is comprised of an inverting/doubling charge pump and a feedback circuit. At full clock speed, the charge-pump portion of the device can produce a nonregulated output voltage that is equal to $-2\ V_{IN}$. The integration of the doubling pump and feedback regulator within the unit enables the absolute value of V_{OUT} to be regulated above or below that of V_{IN}. The TC1142 delivers an output voltage of –5 VDC at a maximum of 20 mA over an input voltage of +2.5 to +5.5 VDC. This note can be downloaded for free from the company's website at www.microchip.com.

Microchip Technology, Inc., 2355 West Chandler Blvd., Chandler, AZ 85224-6199; (480) 792-7200, FAX: (480) 792-7277, Internet: www.microchip.com.

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A spectrum analyzer enables pulse measurements to be acquired over a large frequency range. If the frequency of the signal is accurately yielded, the frequency span can be reduced.

Make radar pulse measurements with a spectrum analyzer

RADAR CAN BE used in a plethora of ways, and many different types of radars have been created to meet the needs of the various applications. The majority of radars operate from 4-MHz-to-18-GHz, though research has begun in the 200-to-300-GHz range. Each application has its own set of measurement requirements, meaning that measurements now cover a wide area of testing techniques, and the expansion into higher bandwidths, along with the continued interest in target imaging has led to frequency agility becoming more common as an effective means of countering many types of jamming. As such, tests such as frequency-switching-speed measurement, hop-sequence verification, pulse-power measurements, and pulse-shape measurements are extremely important.

In his eight-page application note entitled, "Radar Pulse Measurements with a Spectrum Analyzer," author Randal Burnette explains that a spectrum analyzer can be useful for analyzing radar signals because it can characterize them in the time and frequency domains. Although peak pulse power cannot be directly measured using the spectrum analyzer, it can be deduced once the duty cycle of the pulse is known. This is due to the fact that a pulse is not on at all times, but a spectrum analyzer is averaging over time.

A spectrum analyzer enables pulse measurements to be acquired over a large frequency range. If the frequency of the signal is accurately yielded, the frequency span can be reduced, thus lowering the resolution bandwidth to produce a large dynamic range. If the frequency span cannot be reduced, the resolution bandwidth can be reduced independently to eliminate noise in nonpulse frequencies that have the ability to affect the measurement. This application note can be downloaded for free from the company's website at www.agilent.com.

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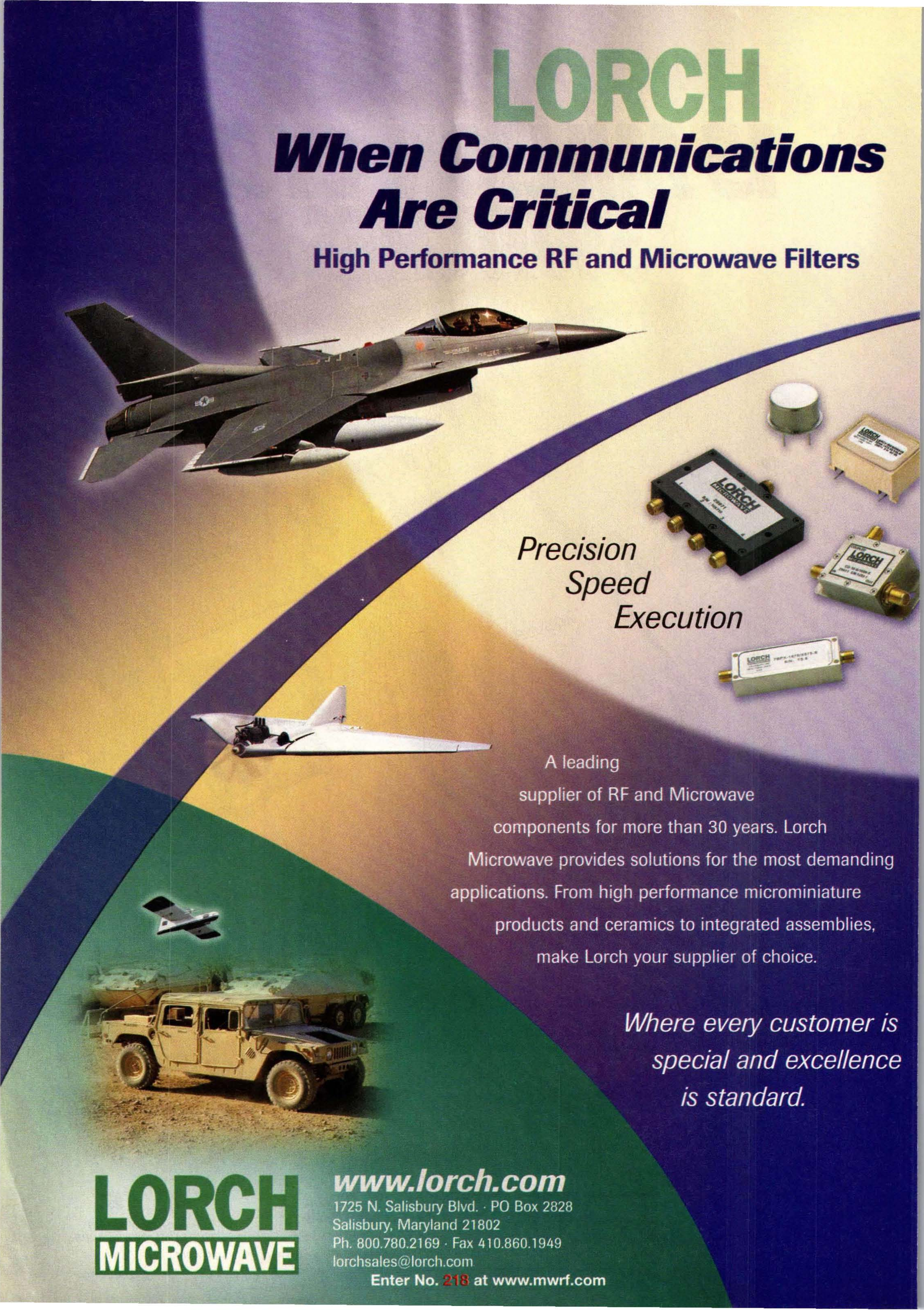
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cover story

400-MSamples DDSs Run On Only +1.8 VDC

This line of highly integrated DDS ICs features on-board RAM and crystal-oscillator circuitry to simplify the generation of agile and exotic waveforms.

JON BAIRD
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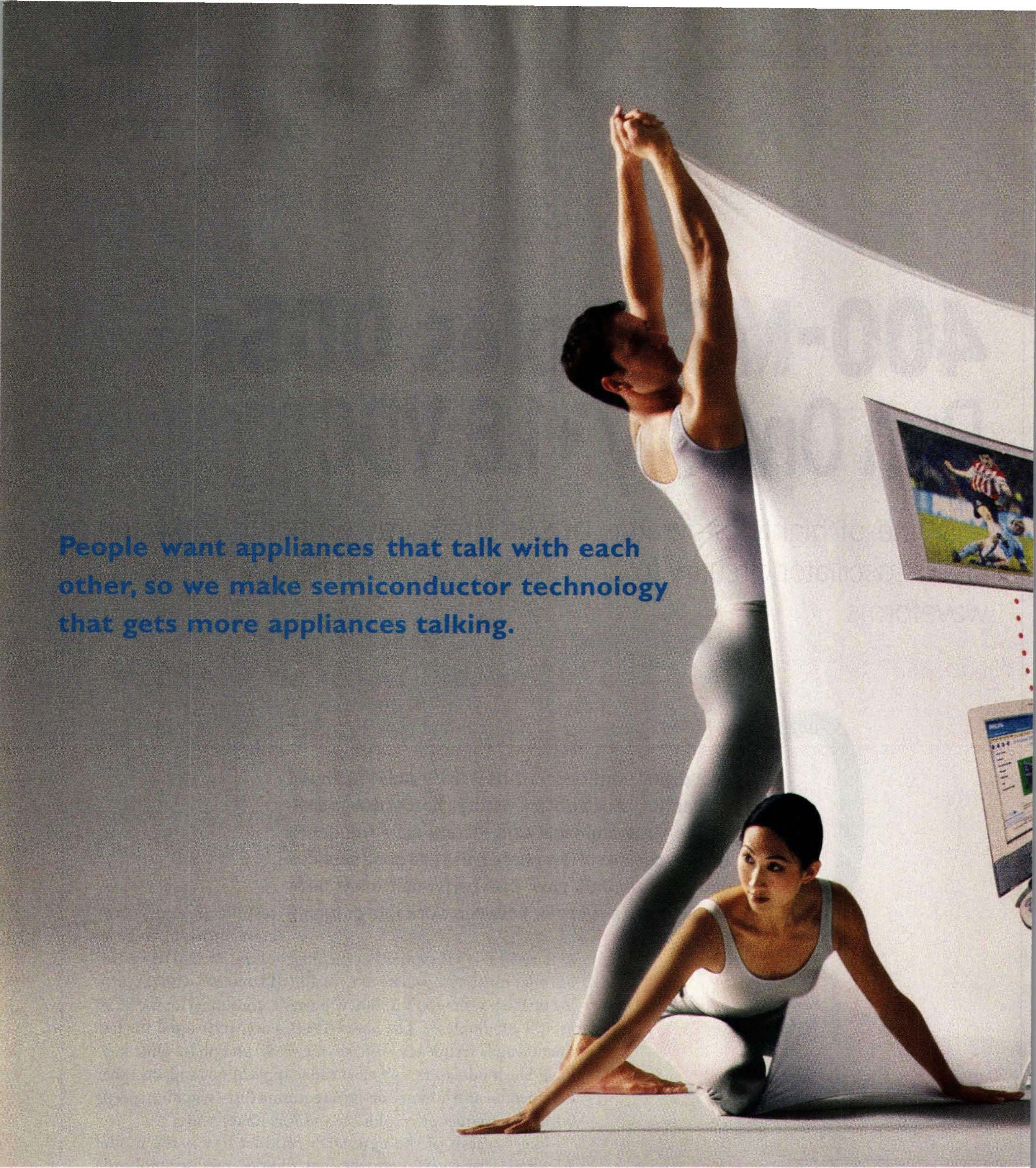
Analog Devices, Inc., 7910 Triad Center, Greensboro, NC 27409; (336) 605-4318, FAX: (336) 605-4187, e-mail: jon.baird@analog.com, Internet: www.analog.com.

Direct-digital synthesizers (DDSs) are flexible integrated circuits (ICs) capable of answering a host of design challenges. Programmable DDS ICs are agile frequency sources capable of low phase noise and good spurious performance. Until now, DDS performance has been saddled with a trade-off between clock rate or tuning resolution and power consumption. But the new 9954 DDS IC and other members of the 995X DDS families offer maximum update rates to 400 MSamples/s without turning up the power—only 180-mW power is consumed for the 9954 at 400 MSamples/s. The new DDS ICs are well-suited for frequency-agile frequency-shift-keying (FSK) and phase-shift-keying (PSK) modulators, as well as radar applications and any other commercial and military designs requiring fast-switching speeds with high frequency resolution and low phase noise.

The flagship of the new DDS product line is the model AD9954, with swept-frequency capabilities, precise amplitude control, multiple profile selection, on-chip 1024 × 32-b random-access memory (RAM), and an integral 14-b digital-to-analog converter (DAC). The IC also includes a phase-locked-loop (PLL) clock multiplier, on-chip crystal oscillator, and a high-speed comparator. Despite its functionality, the AD9954 is designed to operate on a mere +1.8 VDC. A 32-b phase accumulator at the heart of the AD9954 DDS core **(Fig. 1)** provides fine tuning resolution (0.093 Hz for a 400-MHz clock). Essentially, a DDS constitutes a sophisticated numerically controlled oscillator (NCO) that works by incrementing in a controlled manner a value



People want a world without wires where they can record a movie, use the Internet and print from anywhere in the house. Which is why we make the kind of semiconductor technology that lets you get everything connected. It's a total silicon system solution approach that gives you a flexible, reusable, multimedia-capable, completely standards-compatible way to get appliances communicating with each other. Not just across one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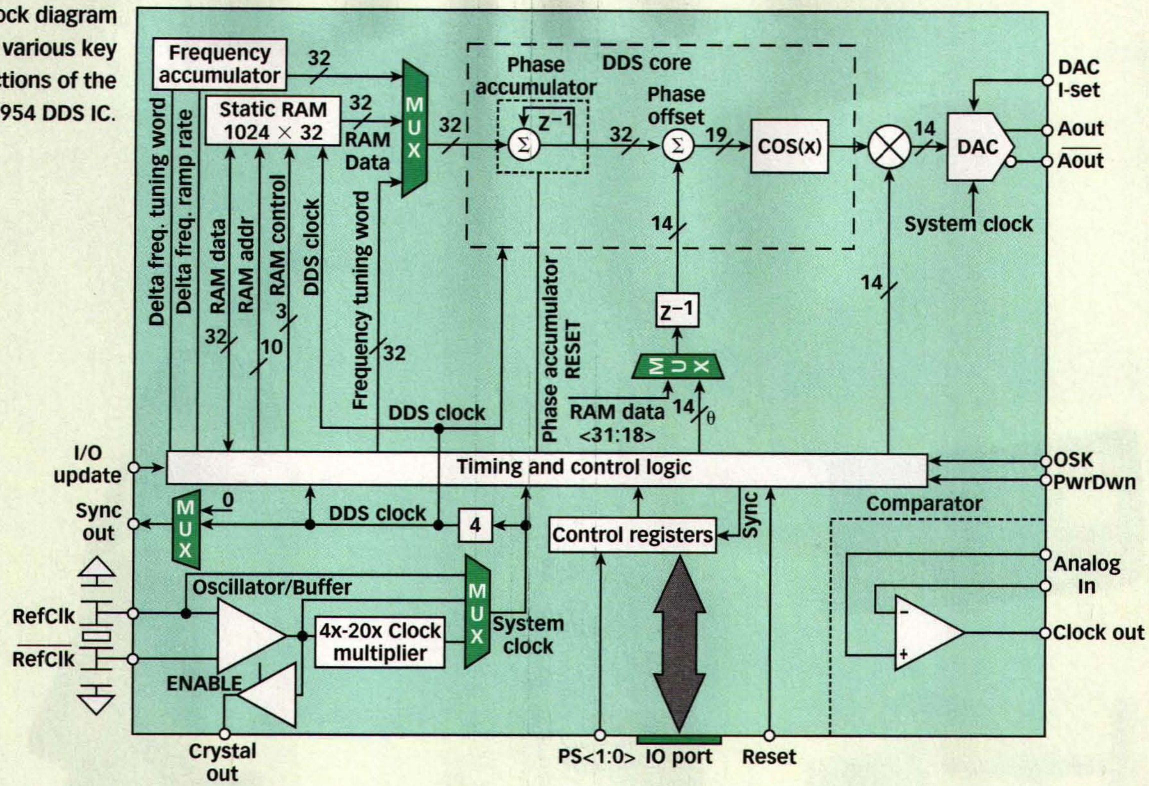
1. This block diagram shows the various key functions of the AD9954 DDS IC.



representing the phase of a sinusoidal waveform. The phase accumulator acts as a modulus M counter and adds a delta-phase word to the existing phase with each clock cycle. The average rate at which the phase accumulator overflows determines the frequency of the generated signal and depends on the magnitude of the delta-phase word. The frequency is derived from the system-clock frequency and the capacity of the phase accumulator (2^{32}) according to the formula $f_0 = (Tf_s)/2^{32}$, where:

T = the value of the frequency tuning word or delta-phase word ($0 \leq T \leq 2^{31}$),
f_0 = the output frequency, and
f_s = the system clock frequency.

Changing the frequency-tuning word of a DDS results in a phase-continuous output frequency that changes immediately. The addition of the phase-offset register provides further control of the accumulator and is a means to shift the phase of the output sinusoid under digital control. The output of the phase accumulator does not directly represent the amplitude of a sine wave. Therefore, following the phase accumulator, a phase-to-amplitude conversion circuit, represented by the cos(x) block in Fig. 1, processes the phase-accumulator result. The output of the phase-to-amplitude conversion represents a digital sine wave that the DAC converts to an analog signal. The phase accumulator generates the digital signal with 32 b of phase information, resulting in a tuning resolution of less than 1 Hz.

The 32-b phase accumulator yields far more phase resolution than can be resolved by a 14-b DAC. If all 32 b representing phases were converted to amplitude, an enormous amount of logic would be required. Therefore, to reduce circuit complexity and to save die area and power, designers commonly truncate the phase information before presenting it to the phase-to-amplitude conversion logic. Truncation leads to a systematic phase error in the signal and the error shows up in the DDS spectrum as spurious energy. The accumulator size, the phase word after truncation, and the tuning word determine the magnitude of these spurious products. As long as the spurious-free dynamic range limitation due to these spurious products remains below that afforded by the DAC, the DDS core does not become a performance restraint. Although the DDS generates frequencies with the 32-b phase accumulator to achieve high tuning resolution, much of the least-significant-bit (LSB) information is superfluous to the DAC. Since the DAC limits spurious performance to a 14-b level, the phase information can be safely truncated without loss of performance. The result is a highly tunable frequency generator with the ability to switch from one frequency to another almost instantaneously, while maintaining continuous phase and good spectral performance. In addition to its high resolution, the AD9954 includes dithering of the signal phase to improve the spurious performance at offsets close to the output frequency. The randomization of the LSBs of each phase word reduces spurious signal power due to the phase truncation that occurs just before the cos(x) block converts the phase.

The AD9954 includes 1024 × 32-b RAM, which can be powered down when not required for an application. When enabled, the RAM's output drives either the phase accumulator or the phase-offset adder. When the RAM drives the phase accumulator, users provide frequency-tuning words through RAM addresses and control the phase of the output by programming the phase-offset register. Programming the RAM to drive the phase-offset adder means the contents of the frequency-tun-

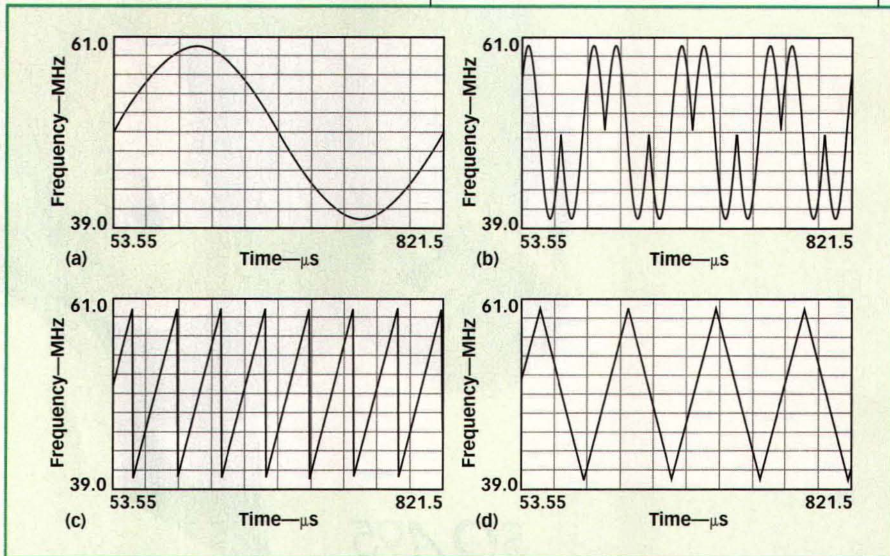
Comparing commercial DDS models.

MODEL NUMBER	CLOCK RATE (MSamples/s)	WIDEBAND SFDR (dBc)	NARROWBAND SFDR (dBc)	TUNING RESOLUTION	MAXIMUM POWER (mW)	MW/ MSAMPLES/S
AD9831/32	25	-50	-72	32 b	120/120	4.8
AD9830	50	-50	-72	32 b	300	6
AD9835	50	-50	-72	32 b	200	4
AD9850	125	-54	-80	32 b	480	3.8
AD9851	180	-53	-85	32 b	650	3.6
AD9852/54	300	-48	-83	48 b	3200/4200	10.67/14
AD9954	400	-57	-80	32 b	180	0.45

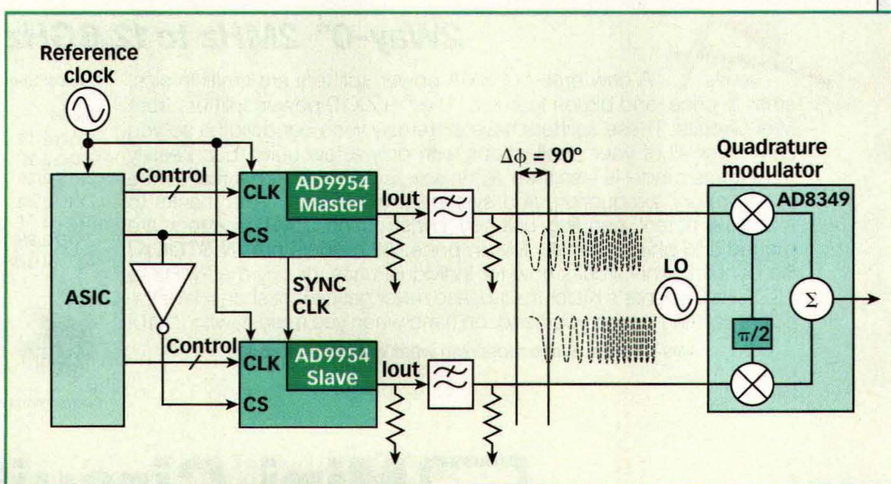
ing-word register sets the DDS output frequency and the contents of the RAM determine its phase. The ability to choose where the RAM contents go makes programming the DDS for PSK modulation nearly identical to FSK modulation. Additionally, the RAM can be separated into four distinct addressable segments, enabling symmetrical or nonsymmetrical phase and frequency sweeping.

The RAM operates in one of five modes: direct switch, ramp up, bidirectional ramp, continuous bidirectional ramp, and continuous recirculation. The direct-switch mode enables easy implementation of FSK or PSK modulation schemes. To design a four-tone FSK modulator, the RAM is split into four segments, with each segment containing a frequency-tuning word. Each segment receives a unique beginning address. Switching the profile-select pins to a particular binary value selects the tuning word from the contents of the RAM segment corresponding to that value. RAM segment 0 corresponds to 00 on pins PS[1:0]; RAM segment 1 corresponds to 01 on pins PS[1:0], and so on. The FSK data presented to the profile pins modulates the output accordingly. Two-tone FSK requires data only on one profile select pin. To accomplish PSK modulation the user would program the RAM to provide the phase-offset word and the frequency-tuning-word register would control the output frequency. Data at the profile pins would then modulate the phase of the output, rather than the frequency.

In radar applications, the ramp-up mode permits users to program the RAM with up to four different sweep profiles when using RAM segmentation. The beginning address of each segment stores the sweep-starting frequency, and successive addresses contain the desired frequency-tuning words comprising the sweep profile. A programmable ramp-rate counter sets the speed at which the sweep occurs. As in the direct-switch mode, the state of the profile-select pins determines which sweep occurs, and the sweep begins when the DDS detects a change in the profile pins or when the user strobes the frequency-update pin. Furthermore, a "no-dwell" bit controls the behavior of the DDS output when the sweep reaches the terminal frequency. With the "no-dwell" bit set true, when the output reaches the terminal frequency the phase accumulator clears once the ramp-rate counter times out.



2. The AD9954 was used to generate sinusoids through continuous recirculation RAM operation (a), sinusoidal frequency sweeps using continuous bidirectional RAM operation (b), linear-frequency sweeps through continuous recirculation RAM operation (c), and linear frequency sweeps through continuous bidirectional RAM operation (d).



3. This is a possible radar application using two synchronized AD9954 synthesizers to drive a quadrature modulator.

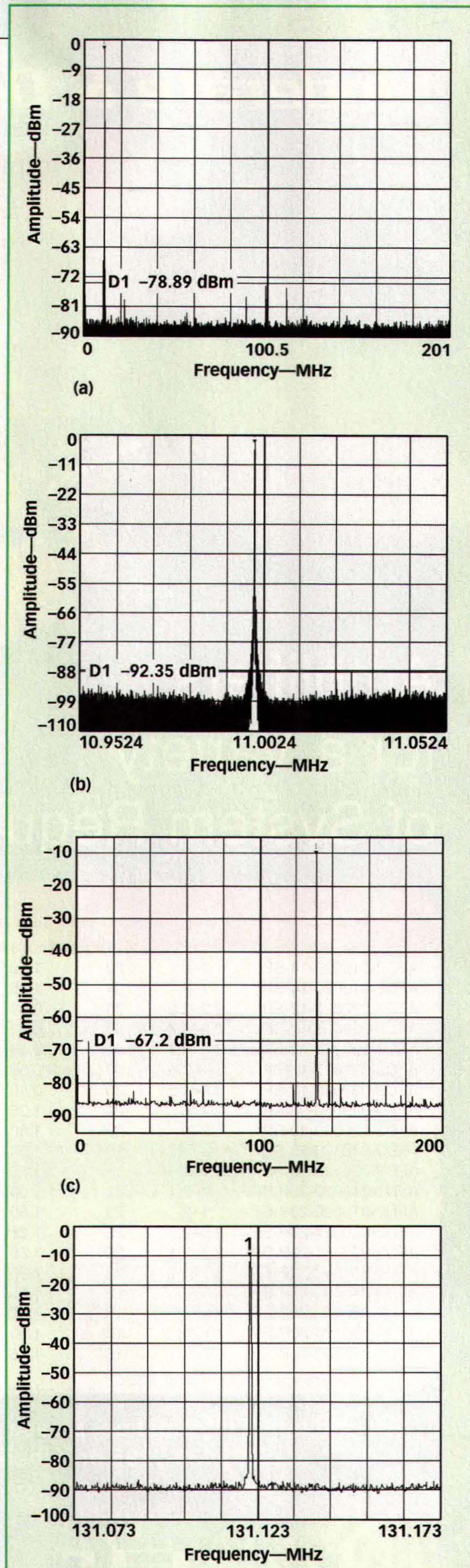
The bidirectional ramp mode enables symmetrical frequency or phase sweeps using a control signal applied to the PS[0] pin. The part ignores signals applied to pin PS[1] and the state of pin PS[0] determines the direction of the sweep. With PS[0] asserted high, the RAM address generator increments to the next address after the ramp-rate timer counts down to 1. If the input to PS[0] remains in a low logic state, the address generator decrements the RAM address generator at a rate that is consistent with the ramp-rate counter. The continuous bidirectional ramp mode operates similarly to the bidirectional ramp, but implements an automatic sweep and repeating symmetrical frequency sweep between two frequencies. The ramp up and ramp down no longer begins coincident with a change in the control pin. Instead, the sweep up and sweep down occurs automatically at the ramp rate.

Finally, in the continuous recirculation mode, the RAM address generator repeatedly cycles through each address in "first-to-last" order. This mode permits automatic and continuous sweeps between two frequencies. From the initial address, the RAM address generator increments at the ramp rate until reaching the terminal frequency in the RAM segment-ending address. Once the RAM drives the frequency-tuning-word data in the final address the address, generator resets and the cycle repeats.

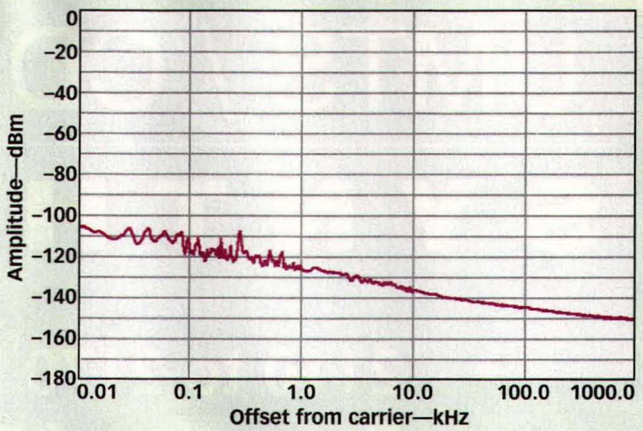
The RAM can store enough frequency tuning words (up to 1024) for a wide range of frequency sweep patterns **(Fig. 2)**. The contents can drive the phase accumulator or load the phase-offset register to yield phase-modulation and phase-sweep patterns as well. Although linear sweeps are possible using the RAM, the RAM size limits the resolution of the sweep to 10 b (Figs. 2c and 2d). Therefore, executing higher-resolution linear sweeps involves an additional mode of operation.

Along with the RAM, additional digital circuitry provides further phase- and frequency-sweep capability, output-amplitude control, multiple DDS synchronization, and support for +5-VDC digital input/output (I/O) signals. The linear-sweep mode is capable of providing frequency sweeps of finer resolutions over a wider range than achievable when using the RAM-based sweep modes. A user simply programs the part with two frequency-tuning words and a delta-frequency-control word to linearly ramp between the two frequencies. The linear-sweep function, coupled with the output-amplitude control, provides a convenient way to implement nonsymmetrical frequency sweeps with precise amplitude control. The output multiplier included in the AD9954 design also allows output-shaped-keying (OSK) or on-off-keying (OOK) modulation formats. The amplitude can be programmed to automatically ramp between two values, and the user determines the value to which the output returns when the ramp completes.

A clock output (SYNC OUT) that coincides with the clock in the DDS core enables users to align precisely the phases of output frequencies on two separate chips as a means of synchronizing multiple DDS devices to a common reference signal. The SYNC OUT signal from a master device feeding the SYNC IN port of a slave device arranges the two so that the user exercises some



4. Measurements were made of the AD9954's output SFDR for wideband (a) and narrowband (b) spans at 11 MHz and wideband (c) and narrowband (d) spans at 131 MHz.



5. The phase noise of the AD9954 was measured for output signals at 98 MHz.

control over the phases of the clocks driving the phase accumulators. A self-clearing bit in the control register adjusts the phase of the slave device by one-quarter SYNC CLK cycle each time it is set. The precise alignment of the DDS clock on separate chips implies the ability to align and control the frequency sweeps originating from two separate devices. **Figure 3** shows the block diagram of a possible radar application using two synchronized devices. The application-specific IC (ASIC) initiates frequency sweeps in both DDS devices with a controlled phase offset of 90 deg. The quadrature modulator following the DDS upconverts the sweep to RF.

The AD9954 includes a DAC, a PLL-based reference-clock multiplier, a comparator, and an oscillator. The 14-b DAC provides 10-mA full-scale current and drives the analog output to a 512-mV_{PP} differential swing when terminated with 25-Ω resistors. This essential component of the complete DDS provides the analog signal needed for system components. An off-chip reconstruction filter is often used to remove image frequencies from the DAC spectrum and, with a carefully managed frequency plan, excellent spurious performance can be attained.

The DDS and DAC may be driven directly from an external clock signal, or a low-frequency clock can be multiplied by up to 20 times using the integrated clock multiplier. The AD9954 sports an integer-N PLL that multiplies input clock frequencies between 4 and 100 MHz to provide system-clock frequencies from 80 to 400 MHz. The PLL provides a convenient way to generate system clock frequencies to 400 MHz without requiring an expensive clock-generation circuit that is external to the part. For additional flexibility, the charge-pump current is programmable from 75 to 150 μA in 25-μA increments; with two voltage-controlled-oscillator (VCO) gain ranges, the user controls much of the loop characteristics of the system-clock generation. A programmable divider sets frequency multiplication between 4 and 20.

The on-chip oscillator works with crystals from 20 to 30 MHz. Placing a crystal (and only two additional capacitors) on the clock-input pins and enabling the oscillator circuit further simplifies the DDS system-clock generation. An output pin also provides a clock signal at the frequency of the crystal oscillator. With minimum effort, two or more AD9954s or other system components can be driven with one low-cost crystal, while maintaining a constant phase relationship between the components. Using its on-chip comparator, the AD9954 can generate square-wave clock signals at frequencies to 160 MHz. In a typical application, a lowpass filter between the DAC outputs and the inputs of the comparator removes unwanted out-of-band spectral content. The filter reconstructs a sinusoidal waveform from the DAC's sampled output and provides a spectrally clean input to the comparator, which squares the sine wave and produces a low-jitter clock source.

The practical output-frequency limit of the AD9954 is approximately 160 MHz. It is the company's first general-purpose DDS to offer a 14-b DAC for outstanding spurious-free-dynamic-range (SFDR) performance. The wideband SFDR measures up to 71 dBc, while the narrowband SFDR measures up to 85 dBc **(Fig. 4)**. Integral nonlinearity measurements indicate the DAC is accurate to at least 12 b and differential-nonlinearity (DNL) accuracy is 13 b. All this performance is achieved while operating on a single +1.8-VDC supply with maximum power dissipation of less than 180 mW. A proprietary DDS algorithm allows much of the digital circuits to operate at clock frequencies lower than that of the DAC, providing tremendous power savings. With all features enabled and operating at the full clock rate of 400 MSamples/s, the AD9954 consumes less than 1/23 the power of the AD9852/54, the company's other two DDS products with frequency sweep capabilities. Yet, its phase-noise performance is on a par with much higher-power units **(Fig. 5)**, approximately −145 dBc/Hz offset 100 kHz from a 98-MHz carrier. The phase-noise floor reaches −150 dBc/Hz at offsets greater than 1 MHz.

Integrating over the 1-Hz-to-10-MHz bandwidth, the AD9954 contributes about 0.6 ps of root-mean-square (RMS) jitter. In some applications, noise in the $1/f^2$ region may dominate system performance and low-frequency noise may not be a critical concern. In Fig. 5, the $1/f^2$ noise region corresponds roughly to the band from 1 to 100 kHz. A second jitter estimate based on this portion of the phase noise measurement suggests the AD9954 would contribute less than 0.2-ps RMS jitter.

The AD995X family of DDS ICs **(see table)** is supplied in 7 × 7-mm 48-lead TQFP packages with an exposed paddle. In addition to the AD9954, the family includes the AD9859, the AD9951, the AD9952, and the AD9953, all of which are capable of 400-MSamples/s operation. In addition, an evaluation board populated with two DDS ICs and a personal-computer (PC) software control interface will be available upon release. P&A: $9.75 to $17.25 (1000 qty.); 90 days. **Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; (800) 262-5643, (781) 329-4799, FAX: (781) 326-8703, Internet: www.analog.com.**

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Integrated Power Amp Covers GSM/DCS/PCS

This tiny packaged power amplifier achieves high efficiency in four bands using integrated passive components for bypass and matching circuitry.

MIKE ZYBURA
Staff RF Design Engineer
BOBBY L. JOHNSON
Application Engineer
RF Micro Devices, 7628 Thorndike Rd., Greensboro, NC 27409; (336) 664-1233, FAX: (336) 931-7454, Internet: www.rfmd.com.

Cellular handset designers yearn for amplification that is compact and simple to use. The +3.5-VDC model RF3133 PowerStar™ power-amplifier (PA) module from RF Micro Devices (Greensboro, NC) may just be the ideal PA solution, since it measures just 7 × 10 × 1.4 mm with integral power control. Based on AlGaAs/GaAs HBT technology, the four-band PA achieves 55-percent power-added efficiency (PAE) with +35 dBm output power in the Global Systems for Mobile Communications (GSM) band and 50-percent PAE with +33 dBm output power in the digital-communications-services (DCS)/personal-communications-services (PCS) bands.

The PA's architecture is a direct extension of earlier work with integrated collector power control. Like the company's three-band model RF3110, the RF3133 provides 35-dB power-control range, but across four wireless bands. Unlike traditional PA modules, in which matching and bypass functions are implemented with discrete surface-mount components, the RF3133 **(see figure)** integrates all matching and bypassing components on the chip. Integration of these components permits *a priori* modification of reactance values based on *in situ* measurement during part fabrication. Furthermore, rather than a random distribution of part values and quality factors (Qs) inherent with discrete parts, capacitor values vary in unison, which stabilizes the impedance presented to the PA.

The four-band (824 to 849, 880 to 915, 1710 to 1785, and 1880 to 1910 MHz) model RF3133 PA module measures just 7 × 10 × 1.4 mm.

The integrated power-control circuitry eliminates the need for additional components, such as directional couplers, detector diodes, and power-control application-specific integrated circuits (ASICs), shrinking the area of the PA printed-circuit board (PCB), reducing overall PA parts costs by $0.90, and even saving the calibration time needed to tune the power-control function (at a cost of about $0.04/second of calibration time). The power-control architecture utilized is accurate and repeatable over process variation. This accuracy and repeatability facilitates faster phone calibration. The measurement uncertainty in the test equipment is greater than the process variation in the PA output power versus V_{ramp} (the power-control pin) with considerable margin. The phone now can be calibrated at a single point, or the calibration can be eliminated. A single-point calibration on a phone with an RFMD PA can save $0.30 to $1.10 per phone. **RF Micro Devices, 7628 Thorndike Rd., Greensboro, NC 27409; (336) 664-1233, FAX: (336) 931-7454, Internet: www.rfmd.com.**

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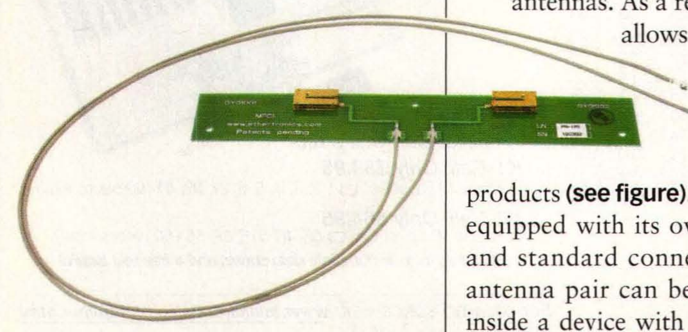
Diversity Antenna Module Broadens Wireless Range

This dual-antenna solution provides designers with drop-in connectivity for MPCI cards, while supporting 802.11a and 802.11b networks.

NANCY KONISH
Technology Editor

Cross-compatibility is the standout feature of the DualNet mini-peripheral-component-interface (MPCI) Internal Antenna Module from Ethertronics (San Diego, CA). By operating on the 2.400-to-2.485-GHz and 5.150-to-5.825-GHz frequency bands, the MPCI module enables compatibility between the IEEE 802.11a and b protocols. With these multiband capabilities, original-equipment manufacturers (OEMs) should be able to easily integrate diversity into their products. They can support today's WLAN standards while preparing for the protocol of tomorrow—without needing an antenna upgrade.This module is designed for the internal MPCI cards that are integrated inside mobile devices. As a result, it leaves the personal-computer (PC)-card expansion slot vacant.

The module comprises two multiband Isolated-Magnetic-Dipole (IMD) antennas. As a result, the solution allows designers to deliver improved wireless range and performance in compact products **(see figure)**. Because it comes equipped with its own ground plane and standard connector cables, the antenna pair can be easily mounted inside a device with minimal interaction with the host system. Its enhanced performance is derived from its increased range/data throughput with improved sensitivity in low signal environments.



This antenna solution is composed of two multiband antennas. It promises to deliver up to twice the range of existing internal-antenna systems.

As a diversity solution, the module features two isolated antennas that deliver greater performance. With isolation above 15 dB, it promises better performance even in tough RF environments.

Thanks to the IMD antennas' proprietary shaping technology, the module controls and redirects the near-field electromagnetic (EM) distribution of the antenna's wave. It optimizes performance by improving signal strength and data quality inside buildings, as well as in noisy environments and fringe network-coverage areas. Within an enclosure, the product's typical characteristics include a peak gain of 2 dBi for the 2.400-to-2.485-GHz band and 5 dBi for the 5.150-to-5.350- and 5.725-to-5.825-GHz bands. Its efficiency is 80 percent in the lower band and 75 percent in the higher bands. The VSWR match is 2:1 across all frequencies. The module comes in a 137 × 23 × 3-mm package. The DualNet MPCI is now shipping for $9.95 each. Contact the company for quantity pricing. **Ethertronics, 9605 Scranton Rd., Suite 850, San Diego, CA 92121; (858) 550-3820, FAX: (858) 550-3821, Internet: www.ethertronics.com.**

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Microwaves & RF 2002 Editorial Index

After [redacted] years of [redacted] developing [redacted] highly classified [redacted] technologies, [redacted] Raytheon [redacted] is [redacted] now [redacted] completely [redacted] open [redacted] to [redacted] discussing [redacted] our [redacted] best-in-class [redacted] technologies [redacted] with [redacted] you. [redacted]

Raytheon has a long heritage developing leading edge technologies for defense and aerospace. But, what we'd rather talk about, is everything we bring to the commercial sector.

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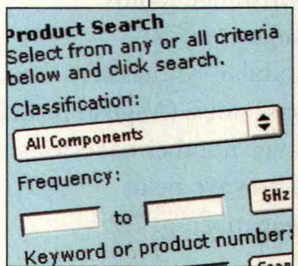
In short, we can help you design, plan and manufacture. Together, we can meet your time-to-market schedules and deliver the technology today's consumers seek. So let's talk.



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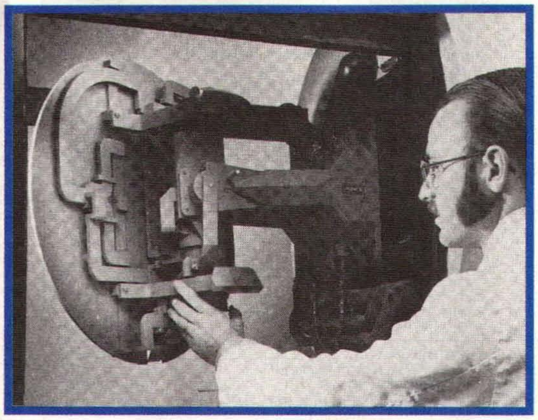
looking back



MORE THAN A quarter century ago, this engineer at Hughes Aircraft (Culver City, CA) worked on the company's modular aircraft- nose-mounted Atlas fire-control radar system. The system was based on planar-array antennas.

next month

Microwaves & RF January Editorial Preview

Issue Theme: Test & Measurement

News

The 11th Wireless Systems Design Conference & Expo (formerly the Wireless Symposium & Exhibition) is scheduled for February 24-27, 2003 at the San Jose Convention Center (San Jose, CA). This full-length preview of the 2003 show will offer a look at the technical presentations to be made next February, including the show's inaugural installment of its Reference Design track, in which attendees are invited to review block diagrams and layouts covering a wide range of applications.

Design Features

January's test theme will be supported by several contributed articles on the subject, including a fascinating look at the use of modulated S-parameters for evaluating high-frequency devices and components, using a broadband-channel, multiple-receiver system. In addition, authors from Agilent Technologies will describe some standard techniques for performing RF measurements on 2.4-GHz Bluetooth systems, while authors from LeCroy will also address Bluetooth measurements at baseband using a high-speed oscilloscope. Finally, antenna designers will point of the importance of high isolation between elements in multiband antennas, while software developers will tackle models for photonic-bandgap (PBG) structures.

Product Technology

The January Product Technology section will highlight a new line of precision impedance tuners, one family for performing harmonic measurements simultaneously at fundamental, second-harmonic, and third-harmonic frequencies, another for making millimeter-wave measurements from DC through 65 GHz. Additional Product Features will detail a powerful automated test system for evaluating the performance of cellular telephones following the new E-911 emergency requirements, as well as a set of low-cost broadband amplifiers for 40-Gb/s OC-768 applications.

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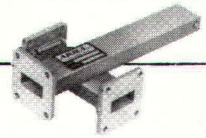

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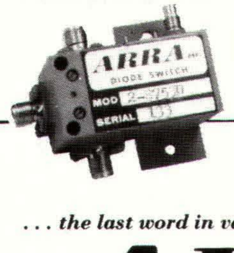

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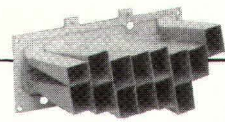

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